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THE HEXTHORPE ACCIDENT.

THE Report of the Board of Trade in reference to this accident has now been issued; and, as was to be inferred from the circumstances attending it, the suspension of the block is one of the points strongly commented upon. Major Marindin's reports are invariably clear and to the point, and in the present instance he is not slow to indicate where the chief blame rests or where the causes contributory to the accident are to be found. To the neglect of the driver and fireman of the Manchester Sheffield and Lincolnshire train in not making themselves acquainted with, and acting up to the regulations issued to them for the conduct of the traffic on the day in question, was the collision in the first place due. He is of opinion that the arrangements made for working the traffic were such as would have insured safety, provided the rules, special and ordinary, had been strictly carried out. No doubt this was so; but in railway working, as we have already observed, the risks to be encountered in case of negligence in carrying out instructions are of such a character, and of so serious a nature, that it is always desirable, where such can be done, to overlay one precaution by another, so that, should any failure arise in relation to the one, there may be another to fall back upon. It is this which makes the block system—the interval of a given space—so material in preventing disasters. And no doubt it is in this sense Major Marindin inquires: First, whether it was necessary to suspend block working at all; and secondly, if this were necessary, whether the arrangements which were made were the best possible. With regard to the first, he readily admits that it would be exceedingly difficult to satisfactorily work the traffic on the section of line in question on the Leger or Cup days in the ordinary manner with so long a block section as that from Hexthorpe Junction to Cherrytree—viz., 1 mile 23 chains—but, considering that the greatest number of trains passing Hexthorpe Junction in any one hour on these two days was fifteen, and moreover that at this time there were two roads in use, he is unable to see that it would have been by any means a work of impossibility. Admitting, however, for the sake of argument that it was impracticable, he proceeds to point out that nothing would have been easier than to adopt a practice in use elsewhere under similarly exceptional circumstances, such as at Ascot during the races, and to divide the long block section into two shorter ones, by the provision at Hexthorpe ticket platform of temporary fixed signals and a temporary hut with the necessary block instruments, and with a code of signals which would admit of a second train being brought up behind another at the ticket platform after being first stopped and allowed to proceed under a caution, exactly as is done at most large junction stations.

These remarks, we doubt not, will bear the endorsement of the majority of those under whose notice the facts of the accident have come, as unquestionably will Major Marindin's further observation: "If the block system is necessary as a safeguard under the ordinary condition of traffic, it is surely all the more necessary when the number of trains is largely increased;" and we are fully in accord with him that "block working should never be suspended upon a line where it is normally in work, if it can by any possibility be avoided."

With reference to the second question which Major Marindin propounds, viz., whether the arrangements made under the suspension of the block were the best possible, we have, probably, little to do; yet it is advisable that we should not pass over his conclusions without comment, inasmuch as they necessarily bear upon and support the argument for the retention of the block. His conclusions are not favourable to the arrangements adopted. "The risk of accident under such circumstances, notwithstanding the issue of carefully drawn up instructions, is shown not only by the catastrophe which actually occurred, but also by the fact that while one of the men concerned did not read the instructions which he had received, the whole of the railway servants with the Midland Company's train were, owing to the culpable carelessness of some official, in omitting to issue to them the printed notices supplied by the M. S. & L. Railway Company, left without any notice of the suspension of block working, and only knew of it by what had been done in former years, and by seeing flag signal men out. The only conditions under which block working could be safely suspended would be that every train should be stopped—not merely 'brought up' or 'checked'—at the block signal cabin at the entrance to the portion of the line on which the suspension is in force, and the driver verbally informed of the state of affairs." This Major Marindin is of opinion, should have been done at Hexthorpe Junction, and no doubt he is right in assuming that had it been done the collision would not have occurred. The safest way, however, and we have every reason to believe, with the sad experience of the case in question before us, the way in which all such exceptional traffic will be worked in future, is under the block. The outlay required for the establishment of auxiliary block posts would be by no means great. The block instruments would, of course, only be required during the special working and would thus be available for ordinary maintenance purposes throughout the rest of the year. The cost of fitting up and maintenance for the period would be a mere bagatelle and be amply repaid by the facilities which it would afford for working the traffic, quite apart from the additional security which, of course, is the main question to be considered.

WHILST no one whose opinion it is important to consider thinks of disputing the necessity for an improved system of technical education in this country, there are great differences as to what the character of the im-

provement should be. Some educationalists favour the "levelling up" process, that is to say, the education of all children alike in technical subjects; but others condemn this scheme as one calculated to involve a vast amount of waste in the expenditure of money, time, and labour, by keeping a large number of children to the practice of crafts for which they have no aptitude, and suggest as an alternative the technical training under the best possible conditions of youths displaying special ability. The latter view is taken by the Council of the Bradford Technical College, and is embodied in a series of resolutions presented by them to the Vice-President of the Council on Education, Sir W. Hart-Dyke, M.P. Further clauses of these resolutions are, "that it is desirable that technical schools be established in the centres of the different manufacturing industries, with special reference to the industry or industries of the locality;" "that no technical education will give efficient aid to the development of our manufacturing industries, unless it is given in schools furnished with the newest and most approved machinery employed in each industry, and given in buildings specially adapted for such machinery," and "that exhibitions entitling their holders to free education in these schools be granted to boys who excel in the examinations in art and science." There are obvious difficulties to the carrying out of the plan suggested by these resolutions, but we have little doubt that the Council of the Bradford Technical College are working in the right direction in advocating it. Full and free discussion is what is immediately needed, in order that all sides of one of the most pressing questions of the day may be recognised and considered before the time comes when Parliament will be asked to pass definite legislation dealing with the subject.

THERE is a probability that the Gülcher Company may once more enter the field wherein it has already done a great deal of excellent work. As our readers are probably aware, circumstances of a nature familiar to those who had any acquaintance with the manner in which electric lighting companies were promoted some five years ago forced the company into liquidation. A scheme of arrangement has been propounded, and is to be submitted to meetings next Monday of the debenture holders and other creditors of the company, whereby a new company will be formed with a nominal capital of £70,000, to purchase the assets of the old company. The capital, under the arrangement, is to be divided into 50,000 preference or "A" shares of £1 each, and 20,000 ordinary or "B" shares of £1 each. The profits —and it may safely be assumed that there will be profits—made in each year will be devoted first, to the payment of a preference dividend at the rate of 10 per cent. on the "A" shares, and the surplus, if any, to the payment of dividends on the "A" and "B" shares ratably in proportion to the capital paid up thereon. The consideration for the sale and transfer is to be the payment of £16,000 in cash to the liquidator of the old company, and the allotment to his nominees of 20,000 "B" shares in the new company, credited as fully paid up. The cash is to be applicable, first, to the payment of all the costs, charges and expenses involved by the winding up of the old company, and the carrying into effect of the proposed scheme, by the action brought by a debenture holder (which, under the arrangement, is to be abandoned), and by the proceedings of the committee of creditors appointed in July last; and secondly, to the payment of the debts and liabilities of the old company, in accordance with the rights and priorities of the creditors; and the "B" shares and surplus cash is to be distributed among the members of the old company, in accordance with their rights and interests. The scheme seems upon the face of it to be an equitable one, and we shall be pleased to see it receive the cordial support of the meetings to be held on Monday, in which case we shall expect the new Gülcher company to participate prominently in the revival of electric lighting activity.

IT is necessary that some sort of supervision should be exercised over theatres to ensure the carrying out of structural alterations which may be essential to the safety of the buildings and their occupants; but it is by no means certain that the Metropolitan Board of Works is the most suitable body to whom to entrust the power of supervision. Recent disclosures have made even those who have hitherto been most tolerant towards the "great spending corporation" hesitate in their faith, and certainly the play-going public will not be inclined to trust much to an official whose attitude is regulated by the extent of the accommodation theatre proprietors afford him in the shape of seats for the play or pantomime. The Board is, however, seeking to obtain increased powers by Act of Parliament. In view of past experience, the theatre proprietors, led by Mr. Augustus Harris, are perfectly justified in their resolve to memorialise the Home Secretary to introduce a Bill vesting the inspection and control of theatres in a department of his office.

YET another portable electric lamp. The undoubted success of Swan, Schanschieff, and one or two others, is likely to be followed by a mania for bringing out miners' lamps, good, bad, or indifferent. Mr. Urquhart has invented an apparatus called the "Sun" portable electric lamp, which the *Times* says will give a *good all-round* light for ten hours. Furthermore, it is stated that the battery, which is a modified form of accumulator with zinc and metallic alloy electrodes, can be fully charged for a ten hours' supply of current in four hours, and that the cost of maintenance is only 3d. for six shifts of ten hours each. One of the funniest points claimed for the invention is, according to the *Times*, that it is absolutely safe when placed in an explosive mixture of gas and air *travelling at a velocity*. Mr. Urquhart's "Sun" is certainly in the ascendant, and he is to be heartily congratulated in getting into the good graces of the electrical representative who ornaments the scientific staff of our ponderous contemporary.

THE United Telephone Company, as we have already informed our readers, is petitioning Parliament for a considerable extension of its powers. Whilst we are desirous of seeing every reasonable facility given for the spread of telephony, we are bound to confess that there are circumstances in this case which make it a grave question whether the United Telephone Company is, in view of the use it has made of the great privileges it already possesses, entitled to the greater powers for which it prays. With a monopoly of monopolies it has singularly failed to satisfy public requirements, and its furtherance of English industry is represented by a minimum in comparison with what similar corporations have effected in other countries. We should be sorry to say anything to retard telephony, but we are exceedingly doubtful whether the United Telephone Company is the right body to whom to entrust powers of so sweeping a character as those it now seeks to obtain. We should be glad to know the opinion of our readers upon this subject.

ELECTRICALLY-WORKED TRAMWAYS.

THE report on the two years' working of the Bessbrook and Newry Electrical Tramway, presented to the Institution of Civil Engineers in the paper recently read by Dr. Edward Hopkinson, gives some data of a very interesting character. The line has been in regular work for two years, and as might have been anticipated, considering the experience obtained by the designer in the construction of former work, its success has been assured. With the equipment of the line we shall not at present deal, though many features of an interesting character are here presented. The locomotive, for instance, consists of a passenger car carried on two four-wheeled bogies, the front bogie carrying the motor—an Edison-Hopkinson dynamo—and driving gear, the whole weighing 8¼ tons.

But it is not to the locomotive cars or wagons in an electric tramway that the chief interest attaches. Any good dynamo we might say will serve as motor for an electric locomotive, and driving gears might be devised endless in design, all, we might say, equally efficient in reducing the speed down from that of the motor to that of the driving axle. With the introduction of Mr. Renold's steel chain used on this locomotive, the mechanical difficulties may be said to have been solved, and we can now employ worm, chain, or spur gearing according to the requirements of the case with equal chances of success. The behaviour of the chain employed by Dr. Hopkinson is eminently satisfactory. It has been in constant use we are told for 18 months without showing signs of wear or stretching, so that for this class of work chains may be in future used with every confidence. The arrangement of the motor and driving gear is now a simple mechanical problem which any engineer worthy the name can successfully tackle. Notwithstanding the many speed-reducing combinations in all shades of complexity for which patents have been from time to time granted, an efficient gear suitable for electric locomotion can be produced any day to order, and that without taking advantage of any of the patented gimcracks.

The question ever asked when a new scheme is proposed is, What will it cost? or, How will it compare with this or that system already in use? and to these questions Dr. Hopkinson's paper furnishes the answers. There was abundant water-power available for the working of the line, and with power thus supplied to the generator through the medium of a turbine the cost was not to exceed that of steam traction on a similar line. This condition has been fulfilled, and in an appendix, tables are given showing both the cost of construction and cost of working. The latter comes out at 3·3d. and 4·2d., respectively, as the average per train-mile for periods extending over five and six months in the slack and busy seasons. The cost per train-mile is, we think, a rather misleading quantity for comparison. It is the cost per *ton-mile* that should be given, since the revenue derivable from the working could only be computed on a basis of tons carried. It should be added that these figures do not include anything for depreciation on the capital of £2,500 expended in construction or for the general supervision of the line.

The continuous conductor, which is laid midway between the rails and carried above ground on wooden insulators, is of channel-sectioned steel connected at each joint by a strip of soft copper. The rails serve as a return. One is struck by the small amount of earth leakage in this line, its insulation resistance, under unfavourable circumstances, reaching from 900 to 1,000 ohms per mile. With 250 volts this means a loss of ¼ ampère, or one-tenth of a horse-power per mile. Here the conductor is more advantageously situated than on the Blackpool line, where with 220 volts the leakage was found to vary from 30 to 100 ampères. In the latter case, in order to meet the requirements of ordinary traffic, the conductor had to be placed underground, and though much of the leakage may have been due to bad insulation at the start, undoubtedly the temptation to leakage, if we might so call it, is increased in conductors so placed.

In comparing the cost of working his line with that of a similar line worked by storage batteries, Dr. Hopkinson arrives at the conclusion that the former is by far the more economical. Fifteen months ago, when writing of the Blackpool tramway, we stated that the only difficulties in the way of direct working were due to the insulation and maintenance of the line. We remarked that if these difficulties could be surmounted there would be great gain in direct working as compared with storage battery working. We say again to-day it is simply a question of the conductor *versus* the battery. In the country Dr. Hopkinson's channel steel is all right, in a town it is not permissible, and the inexpensive conductor becomes an expensive affair placed underground and comparatively inaccessible. What is the first cost of this conductor as compared with the first cost of the batteries? What is the cost of its depreciation and maintenance as compared with that of batteries? Assume that the battery is one-fifth of the total weight moved, and that its efficiency is 70 per cent., then 56 per cent. of the electrical energy given out by the generator is available to move the useful load. In the direct system will the combined losses due to conductivity resistance and leakage reach 44 per cent.? In batteries the maintenance is not less than 30 per cent.—Dr. Hopkinson assumes 40; in direct working will the sum spent in maintaining the conductor in a state of efficiency equal that spent in keeping up the batteries? It is on the answer to these questions that the future of electric locomotion to a great extent depends.

PRACTICAL ELECTRICAL MEASUREMENT.

By J. SWINBURNE.

(*Continued from page* 581.)

Measurement of Alternating Currents.

On coming to this question one feels inclined to copy Charles Lamb and begin this chapter by saying "You cannot measure alternating currents."

Before going farther, a digression may be made upon the way alternating currents are generally discussed. It is usual to assume that the curve of electromotive force of an alternating current machine is a curve of sines, or simple harmonic curve. This is quite unwarrantable. The curve of electromotive force of an alternating current machine may be almost any periodic curve which, when plotted out in the usual way, with the time along the axis of x and the electromotive force along y, will have no part of it at right angles to x. In 1881 Prof. Joubert made some elaborate tests of a Siemens alternating current machine, and found the curve to be approximately a curve of sines. On the strength of this it has been loosely assumed that all alternating current machines give curves of sines. To those who prefer simplicity of mathematical treatment to truth, such a temptation is very strong. In dealing with coils or circuits which have coefficients of induction which are constants, as, for instance, a Siemens voltmeter, the back electromotive force at any instant varies as the rate of increase of the current. Now the rate of increase of the sine of an angle compared with the angle is equal to the cosine of the angle, and the rate of decrease of the cosine of an angle as the angle increases is equal to the sine of the angle. In addition to this it must be remembered that the sine of an angle is numerically equal to the cosine of that angle plus a right angle. It is thus easily seen that those who prefer to make the data fit their mathematics are sorely tempted to treat an alternating current as a curve of sines, and to deal with coefficients of self and mutual induction where such things cannot well be said to exist. This tendency to assume simple laws so that

they admit of mathematical treatment does double harm, because the assumed laws are more or less wrong, and because electricians have a curious respect for mathematics, so that writers who introduce formidable looking expressions are always supposed to be authorities, and empirical laws are accepted and the real laws are not investigated. As an example one may mention the laws of friction and speed, a question of great importance in shafting; and the laws of the relation of horse-power to speed in steamers. Coming nearer home, we have various assumed laws as to the relation of the light to the power of incandescent lamps, and of the life and the efficiency. Perhaps the best instance is in dynamo construction. Probably nothing has done so much to disseminate ignorance about dynamo machines as the various empirical formulæ which have mostly come to us through German periodicals.

On objecting to the curve of sines assumption, the writer has been told that even if the dynamo did not give a curve of sines of its own accord, there were properties in a system of converters which compelled it to do so, something of the nature of harmonic flywheels. The writer has never come across these. He has also had it pointed out that any periodic function can be represented by a series of simple harmonic functions by Fourier's theorem. That sounds impressive and convincing, but it does not amount to anything. Unless the curve is known the coefficients of the separate terms cannot be found, and if they could the terms could not be dealt with separately when dealing with circuits with iron cores.

As already mentioned, different types of machine give different no load curves. A Westinghouse machine gives a saw tooth curve with the points somewhat rounded over. A machine patented by the writer last year gives a saw tooth with the points still sharper. In machines with a large air space the rounding over is generally greater, so that the curve somewhat resembles the curve of sines.

In dealing with the full load curve it has sometimes been assumed that the armature electromotive force remains the same and that the terminal electromotive force can be obtained when the armature resistance and coefficient of self-induction are known. With regard to direct current machines the expression "self-induction of the armature" has already been objected to as meaningless; in alternating current machines the term might be used, but as a rule there is no constant coefficient of self-induction. The assumption that an alternating current armature has a constant coefficient of self-induction is, of course, convenient for use with the assumed curve of sines. Prof. Joubert treated the armature of the machine he tested as having a coefficient of self-induction. It may have been that he could not resist the temptation, or it may be that in a Siemens machine of the old type the wires of the armature coils are, comparatively speaking, so far from the iron of the field-magnets that the armature actually behaves as if it were in air and had a coefficient of self-induction. In discussing alternating currents, however, we must not consider old types of machines. Good as was the Siemens as originally brought out, modern knowledge does not design machines like it. Most machines have iron armature cores now. In some, such as the Westinghouse or Ferranti, there is always an air space, in others the armature cores almost touch the poles in passing.

A glance at what goes on will show how complicated the action of an alternating current machine is. At one position the armature current tends to increase the total induction through the field-magnets, at another to lessen it. In the intermediate position it is in many cases possible to describe a circuit round the active part of the wire, a small part of this being across two small air spaces and the rest being in unsaturated soft iron. This opposes any change of the current. In addition to these any alteration to the magnetisation of the field is again opposed by Foucault currents. It is incorrect to call all this self-induction and treat it as if it had a constant coefficient. The curve of the machine also depends on what is going on in the external circuit. If the dynamo is feeding 100 transformers, each at half load with the iron not saturated, the curve will not be the same as when it feeds 50 fully loaded transformers with cores highly saturated at each extreme.

It is questionable whether such terms as self-induction and mutual induction are properly used when there are iron cores, and therefore no constant coefficients. Unless the induction is split up into magnetising force and magnetisation one cannot well think of self and mutual induction, and it is simpler to neglect the magnetising force and consider the magnetisation increased to make up for it. Instead of varying coefficients of self and mutual induction, it is much easier to think of varying electromotive forces produced in the circuits. The back electromotive force at any instant can then be called the instantaneous back electromotive force. To talk of the self and mutual induction of the coils of a transformer when there is a closed iron core is very roundabout. Self-induction and mutual induction are also apt to be confused with magnetic induction, especially as they are so often discussed together.

The first thing to consider is what we want to measure. People talk loosely of an alternating electromotive force or current of so many volts or ampères, and sometimes mean one thing, sometimes another, and sometimes nothing. Let us suppose the nature of alternating currents not understood, and imagine an electrician investigating their properties with a view to a system which would admit of his obtaining the information necessary for working an installation by suitable measuring instruments. This method of dealing with the subject was, by-the-way, alluded to by Prof. Ayrton in a discussion at the Physical Society. The first thing the electrician will want to measure is the power. In an ordinary wattmeter the force acting on the moving coil at any instant, or what may be called the instantaneous force, varies as the product of the instantaneous electromotive force and the instantaneous current. So that if the moving coil has too much inertia to vibrate with the varying force, the mean force varies as the mean product of the electromotive force and current. A wattmeter, assuming there is no self or mutual induction, therefore measures the power. If the part of the circuit in which the power is measured consists of a resistance which gives no back electromotive force, the current always varies with the electromotive force; but if a back electromotive force existed the current would not vary with the electromotive force, but the wattmeter would at any instant measure the product, and would therefore still read the real power.

Having measured the power, the electrician would attempt to split it into two factors corresponding to electromotive force and current in direct current work. He would first try to measure the mean electromotive force and the mean current, but not only would he find that no known instrument will measure it, but that the measurements would be useless if taken. For instance, to make the case simple, suppose an electromotive force were alternately 2 volts and 4 volts for a second each. The mean electromotive force would be 3 volts. If there were 1 ohm in circuit the current would be alternately 2 ampères and 4 ampères for equal times. When there were 2 ampères and 2 volts the power would be 4 watts, when there were 4 volts and 4 ampères there would be 16 watts. The mean power would therefore be $(16 + 4) \div 2 = 10$ watts, but the mean electromotive force and current would be 3 volts and 3 ampères, their product being 9. As the electrician wants factors of the mean power, the mean electromotive force and current are of no use whatever. If there were a varying back electromotive force, the product of the mean electromotive force and current would be still wider of the mark. As the power varies as the square of the electromotive force and as the square of the current when there is only resistance in circuit, the electrician would turn towards the dynamometer, wound as a voltmeter or ammeter, in which the instantaneous force varies as the square of the instantaneous electromotive force or current, and the mean force varies as the square of the mean electro-

motive force or current. Such instruments, if graduated to read the force, not the square root of it, would read the power. Thus if the high resistance dynamometer were in shunt to the resistance it would read the power, and the low resistance dynamometer in series with the resistance would also read the power. In one case the reading, in volts squared, would have to be divided by the resistance, and in the other multiplied by it, to give the power. Still the readings are not what are wanted, as power varies as the square of electromotive force or of current. If the instruments are now graduated to read the square root of the mean force the factors desired are obtained. Thus, to find the power spent in overcoming a resistance, the square root of the mean square of the electromotive force is multiplied by the square root of the mean square of the current, and the result is obtained in watts. These factors may be called the virtual electromotive force and virtual current, as the other expression is cumbrous. The name is fitting, because the virtual electromotive force and current are not the real mean electromotive force and current, but they are such that when working on resistance the power, $W = \frac{E^2}{R} = C^2 R$, E and C being the virtual electromotive force and virtual current. Thus in the case taken above of 2 and 4 volts on 1 ohm, the voltmeter measures the mean of the two forces, 4 and 16 corresponding to the squares of the instantaneous electromotive forces. This mean is 10, and the dial is graduated to read the root of it. The ammeter similarly reads the root of 10, so that the product is 10, the real power in watts. The power could also have been determined by either instrument alone as the resistance was known.

If, however, there is a varying electromotive force in the circuit as well as a resistance, the product of the virtual electromotive force and virtual current no longer gives the power. For instance, there might be 4 virtual volts when, on account of the back electromotive force, there was no current; and there might be 4 virtual ampères later on with no virtual volts, caused by a forward electromotive force. The real power would then be zero, but the product of the virtual electromotive force and current would be 8. It is almost needless to remark that with a constant current the virtual and real current or electromotive force are the same.

The electrician has now got something to go upon. In an installation he wants first to know the power given out by his machine. He can get that with a wattmeter. Next he wants to know how that is made up, because a given power might be over-running a few lamps or running a number dull and heating the leads. As already explained, the product of the virtual electromotive force and current does not always give the real power in watts. If transformers are used the error depends very much on their construction. If the current varied with the electromotive force the curves of the current and electromotive force would be similar, and might be plotted out to coincide exactly. This is what happens on resistance. The curves might be exactly similar, but the rise and fall of the current might take place after that of the electromotive force. The curves though similar would then differ in phase, and the product of the virtual electromotive force and current would not give the power. Further, the current curve may be of different form, either retarded or not retarded, when the product of the virtual electromotive force and current will again differ from the real power.

The error due to the difference of form and of phase depends very much on the transformers used and on the dynamo. Thus, in parallel distribution, closed iron circuit transformers cause a very small error compared with open transformers. For instance, imagine a closed circuit transformer with iron so soft that its permeability is infinite, with no persistent magnetism, with wire of no resistance, and with the same number of turns in the primary and secondary. The transformer would then modify the curves in no way, and it would make no difference if it were cut out and the machine coupled direct to the external circuit. If the secondary had more turns its electromotive force would be increased and its current diminished in proportion. Suppose now that the wire has resistance, the effect is then just the same as if the dynamo worked direct on the external circuit with this resistance inserted. The electromotive force and current curves are still similar and the same in phase. Suppose now the iron is not infinitely soft the current curve will be modified in an irregular way, and persistent magnetism and Foucault currents in the core will also modify both the electromotive force and current curves, so that they are no longer similar nor of the same phase. The difference between the product of the virtual readings and the real power may not be great, but its amount depends on the construction of the transformers, and it is beyond the scope of these articles to go into the question of alternating currents generally.

(*To be continued.*)

TELEPHONIC COMMUNICATION BETWEEN LIGHTHOUSES AND THE SHORE.

THIS important subject engaged the attention of the Plymouth Chamber of Commerce on Friday, when Mr. Bayly pointed out the great importance it was to captains and others to know the state of the sea to the windward, as for instance in the case of a captain having his vessel at Dartmouth and being able to communicate as to the state of the weather at Eddystone or the Lizard. Again, communication by telephone would be eminently useful in case of an accident, when assistance could be at once summoned from different points. In the case of the *Soudan*, although the vessel ran aground within half a mile of the coastguard station and within 20 miles of Plymouth, 12 hours elapsed before assistance could reach her. The result was that that fine steamer was now lying a wreck off Salcombe harbour. He considered that all lighthouses should be put into communication with the telegraphic system and the different coastguard stations connected by telephone. The cost would be small. He moved a resolution to the effect that a memorial should be addressed to the Admiralty, the Board of Trade, and Trinity House, urging that the coastguard stations should be put into telephonic communication with the telegraphic system of the country, and that communication should be established between lighthouses, lightships, and the shore. A discussion ensued on the proposition, in the course of which Mr. Groser mentioned that last year he had an opportunity of having a conversation on that very point with the secretary to the Board of Trade, who was heartily in sympathy with the proposition. However, the difficulty was that there were four Government departments concerned in the matter, and they could not be induced to see eye to eye. The difficulty with regard to the use of the telephone by coastguards appeared to be that the greater part of their time was spent in patrolling, and that it would be necessary to appoint someone to listen for the telephone. He did not think, however, that such an objection as that would have any great force, and he advised them to continue pegging away. When the *Schiller* was wrecked on Bishop's Rock, many scores, if not hundreds of lives might have been saved had there been proper means of communication with the shore. He called the attention of the Post Office to the matter at the time, with the result that all seaside offices were put into night communication with central offices. Mr. Bellamy remarked that such nations as Denmark and Germany possessed splendid telephonic and telegraphic facilities along their coasts. A partial promise had been obtained from the Trinity Masters that telephonic communication should be established between Eddystone Lighthouse and the shore, but they were afterwards informed that it was feared that it would interfere with the work of the assistants. Eventually the resolution was unanimously carried.

SMITHFIELD CLUB SHOW.

ALTHOUGH the electric light was conspicuously absent from the show itself, a striking exhibit at the entrance was a shop occupied by *Messrs. J. E. H. Andrews & Co.*, and lighted by two arc lamps from a Paterson and Cooper dynamo, driven by a "Stockport" gas engine of 2 H.P. nominal. These engines have recently been much improved, the slide valve having been done away with, and the working parts reduced to the greatest simplicity. The lubrication necessary in these engines is very little compared with other gas engines, a point largely affecting the question of economical working. The company has for some time past lighted not only its own offices at 80, Queen Victoria Street, by incandescent lamps, but several other offices in the same building, and the engine has proved itself thoroughly suitable for this purpose. *Messrs. Pfeil & Co.* had their usual stall in the entrance, at which their new speciality, manganese steel, was shown in a variety of forms, and its qualities demonstrated. A feature at this exhibit is the "Electrician" lathe, a tool well spoken of by those who have used it for electrical, optical, and other special work. At several of the stands of the leading manufacturers of engines was shown some improved type, bearing a notification that it had been specially designed for electric lighting work. *Messrs. R. Hornsby & Sons* had on view one of their new overhead vertical steam engines, similar to those shown at work at the American and Manchester exhibitions. *Messrs. Robey & Co.* also showed several portable and other kinds of engines which have been found so suitable for different kinds of electric work. At *Messrs. Marshall & Sons'* stand were shown, amongst others, three engines, of which the following is a description:

(1.) A 10 H.P. portable engine of the compound type, with Hartnell's patent automatic expansion gear to the high pressure cylinder, the whole engine and boiler suitable for a working pressure of 140 lbs. per square inch. A special water heater is arranged on the side of the boiler barrel, and the whole of the engine throughout is designed to give the utmost economy in fuel with steady running under varying loads.

(2.) A 10 H.P. compound stationary engine and boiler of the underneath type, mounted on wrought iron girder foundation, and of ample construction for a working pressure of 140 lbs. per square inch. The engine is fitted with patent automatic expansion gear, improved sight feed lubricators, steam trap for draining the cylinder jacket, and all the latest improvements for insuring thorough efficiency with the utmost economy in fuel. The boiler is made with steel shell and internal fire-box of Lowmoor iron, double rivetted in the longitudinal seams, and thoroughly stayed for the working pressure above named.

(3.) An 8 H.P. horizontal fixed engine, class "B," fitted with patent automatic expansion gear; this engine is self-contained on a cast-iron bedplate, both bearings being on the same bed.

Messrs. Davey, Paxman & Co., who, in the great competitive trial held in connection with the Royal Agricultural Society's Show at Newcastle, this year, were awarded the only prizes given, namely, £200 for their 8 H.P. compound portable engine, and £100 for their 8 H.P. single cylinder portable engine, exhibited engines similar in construction to those which were tried on that occasion.

THE BRADFORD CORPORATION AND ELECTRIC LIGHTING.

AT the monthly meeting of the Bradford Town Council, held on Tuesday last, the Gas Supply Committee submitted a resolution proposing to lay down an installation of electric lighting, the expenditure being limited to £15,000. The committee until lately had no intention of immediately pressing the project, and were contented to proceed with a view to carrying out a scheme in time for next winter, but the number of firms and private persons in the town desiring to use the illuminant is so great, that they felt that they must either at once take steps for supplying it under the Provisional Order which they have obtained for that purpose or that they could not reasonably expect to prevent local companies or electricians from taking the action from which they refrained. Of the £15,000 for which the committee intend to ask, £8,000 only, it is expected, will be required for the plant which will be first laid down; but of course it is necessary, especially as no detailed scheme has yet been framed, to have a considerable margin to cover the cost of maintenance and other contingencies, such as small extensions from the main cables which it may be necessary to make from time to time. The electric lighting works will be built on a site belonging to the Corporation in Bolton Road, from which two main cables will be laid, one to the Town Hall and along Market Street, and a second up Darley Street as far as the Free Library, both of which public buildings will probably be lighted by electricity. From these cables it will be possible to light the most important parts of that portion of the town which forms the centre of business operations, and any adjacent streets in which the illuminant is required may easily be added to the area of supply. As regards extension, it may be pointed out that the works in Bolton Road will be erected as part only of a larger scheme, which may be fully carried out if the first installation, which is in a great degree experimental, and intended to act as a gauge of the success with which electric lighting is likely to meet in the town, justifies the Corporation in enlarging their scale of operations. By making their works part only of a larger scheme the Corporation will likewise be able to execute them with the smallest prospect of waste when extension becomes necessary. The cables will be laid down underground instead of being carried overhead, as is the case in connection with the installations already working in Bradford. This, of course, will be one advantage which the ratepayers will have by the supply being in the hands of the Corporation, private firms and companies having no power to lay their cables below the ground. Before the scheme is settled in any detail it is probable that the committee will visit other towns in the country where installations of electric lighting have been made, with a view to adopting the most efficient and suitable system.

It may be added that negotiations have been carried on for the purchase by the Corporation of the plant and property belonging to Messrs. Schmidt, Douglas and Co., in Bradford, as a nucleus of their supply, but the parties were unable to come to an agreement as to the price, Messrs. Schmidt, Douglas & Co. asking £22,000. It was considered better for the Corporation to erect its own works than to pay this sum, and the negotiations accordingly fell through.

Commenting upon the decision of the Gas Committee, the *Bradford Observer* says:—"There cannot be the least doubt that, at the present stage of electric engineering, the new enterprise of the Corporation can with proper management be made remunerative. The electric light is not yet a commercial competitor with gas, as regards the mere quantity of illumination; but the two commodities cannot be directly compared. The well-known sanitary and colour-showing advantages of the electric light are, for many purposes, of value which cannot be appraised by the difference in cost; and the Corporation, seeing that it interfered to stop private enterprise, should have met the demand long ago.

Competition in Telegraphy.—We learn that the American public complains of the increase in tariff which in many districts has followed the absorption of the Baltimore and Ohio lines by the Western Union. From Chicago there come reports that a powerful syndicate of capitalists has been formed with the view of establishing a telegraph system to compete with the Western Union.

INTENSITY AND CONSUMPTION OF THE ORDINARY SOURCES OF LIGHT.

By C. HEIM, of Hanover.

(*Continued from page* 580.)

Arc Lamps.

Among the many constructions at present in use I have measured three which afford very different strengths of light. In order to obtain as uniform burning as possible, there was used as the source of the current a compound machine of 100 v., which therefore required the introduction of a considerable resistance. The machine was also, in order to engage it fully, loaded with considerable rheostat resistances. Various spring galvanometers and a torsion galvanometer served for measuring the current and the tension. As upper carbon there was used in all cases a cored carbon; the lower carbons were homogeneous.

On comparing, as it was done here, two sources of light of so different colours as an arc lamp and a petroleum lamp, the difference of colour on both sides of the photometer screen is certainly considerable, and it appears as if an accurate adjustment would here be out of the question. Hence arrangements have been proposed for partially compensating the difference of colour, such as the compensation photometer of Krüss. Experience shows, however, that with some practice the observer can soon carry out the adjustments with an accuracy which falls little behind that reached with lights of the same colour. The results obtained by both observers with arc lamps differed from each other throughout by only 5 per cent. I am convinced that these discrepancies are mostly due to those periodical fluctuations in the intensity of the light, unavoidable with arc lamps, and only to a small extent to uncertainty of adjustment.

The following table contains in the last column the number of candles obtained per mechanical horse-power as conveyed to the driving wheel of a dynamo. These values are calculated on the assumption of a utilisation of 75 per cent. by the dynamo.

Among the figures in the table only the values obtained at 45° give a correct view of the performance of the various lamps. In a horizontal direction the strength of the light fluctuates considerably, increasing or decreasing with every slight variation in the position of the arc. Still the above figures, being obtained from three series of experiments with numerous adjustments, give the mean value of the horizontal strength of the light.

TABLE III.

Name.	Diameter of carbons.	Length of arc.	Angle with horizon.	Light in normal candles.	Electric work in voltampères.	Voltamperes per candle.	Candles per horse-power.
	mm.	mm.					
Pieper (by circuit lamp) ...	above 6·7	2	0	126	160	1·27	433
Do.	below 5·0	2	45	377	153	0·405	1360
Piette - Krizik (differential lamp)	10	4	0	220	414	1·88	293
Do.	...	4	45	1420	413	0·291	1890
Siemens and Halske (differential lamp)	14	4·5	0	575	918	1·60	344
Do.	...	4·5	45	3830	912	0·238	2310

It is known that in arc lamps the economy of the lamp is improved by enlarging the size and by increasing the strength of the current, in consequence of an elevation of the temperature of the luminous portion. Thus, if measured at 45°, the Piette-Krizik 8-ampère lamp gave a better performance by 39 per cent., and the Siemens (which had a normal current of 20 ampères) by 70 per cent. than the Pieper lamp at 4 ampères. By increasing the length of the arc the useful effect was somewhat increased in all the lamps, whilst the distribution of light in different directions was more uniform. However, the fluctuations increased also, whence I preferred to set the lamps at a medium length of arc in order to attain the most even burning possible.

Glow Lamps.

The following results of photometric measurements with glow lamps are in part taken from an earlier paper of the author. I have given here only the values for the types at present most in use in Germany as obtained with 16-candle lamps of about 100 v. The tensions were measured by means of calibrated mirror galvanometers. Care was taken that the tension at the terminals of a lamp should not vary perceptibly during the measurement.

The glow lamps were measured only in a horizontal position, so that the axis of the photometer was perpendicular to the plane of the carbon filament (except in the earlier Edison lamps, which were measured in the so-called maximum position). To examine at other angles seems needless, as we obtain at 45° a strength of light which differs very little. Besides, glow lamps can be placed in any desired position in the space to be illuminated, an advantage which is not shared by any other source of light.

To the values found is added the strength of light obtained per horse-power, calculating for the dynamo a yield of 75 per cent. This proportion can at present be obtained with small compound machines, whilst larger improved machines yield up to 90 per cent.

TABLE IV.

Name.	Strength of light.	Electric work in volt-amperes.	Volt-ampere per candle.	Candles per horse-power.	Lamps per horse-power.
Edison (early type)	16	72	4·50	122	7·6
Edison (new type)	16	60	3·75	147	9·2
Swan (early type)	16	66	4·13	133	8·3
Swan (new type) ...	16	56	3·50	157	9·8
Siemens and Halske	16	52	3·25	169	10·6
Bernstein (Electrotechn. Works, Cannstatt).....	16	56	3·50	157	9·8

It had been intended to annex to the above experimental results a comparative view of the cost of illumination with the various sources of light examined. But as all the requisite data are not at present at my disposal, I shall postpone this calculation to a subsequent number of this journal.

Magnesium Lamp.

There may be here added the results obtained with a magnesium lamp of recent construction which has been sent for examination to the above-named Institute by H. A. Grätzel, of Hanover.

Since it has been found practicable to produce magnesium electrolytically on the large scale and the price has consequently fallen within a few years to about one-fifth of its former amount, the attempt has been made to utilise the property of this metal (hitherto little regarded) of burning with great lustre, in the construction of sources of intense light. There can be no doubt that with the increasing application of the magnesium light the technical improvement of the lamps will proceed hand-in-hand. The burner here measured was made for experimental purposes only, but it yields a light burning with sufficient steadiness.

There can be burnt in this lamp as many as eight magnesium ribbons of 2·5 mm. in width and 0·13 mm. in thickness. It is, however, easy to burn any smaller number at pleasure. Even on burning a single ribbon there was no extinction, as it often happened with the earlier lamps. The strength of the light fluctuates more than in a well-regulated arc lamp, but the fluctuations are more gradual, so that they are perceptible only on the photometer screen but not with the naked

eye. They certainly occasion disturbance, and I have sought to eliminate their influence by increasing the number of observations. The greater the number of the ribbons burning, the smaller is the relative amount of these variations.

The white fume, in which state a part of the oxide formed during combustion escapes, found its exit through the ventilation shaft previously mentioned. The escape pipe was firmly connected with a reflector attached to the lamp, so that the lamp could not be used without it. But as I wished to ascertain the strength of light which the lamp yields without reflector, it was pasted over with dead-black paper. In this manner the strength of light for different numbers of ribbons could be conveniently determined. Lastly, as the concave mirror will be used with the lamp in many cases, the paper was removed, and after the polish of the reflector was restored, measurements were made with the reflector. These results of the latter, of course, hold good only for the lamp in question. The aperture of the parabolic reflector had the diameter of 39 centimetres. This is not the place to enter upon the details of the construction of the burner.

For determining the consumption of magnesium, the rolls upon which the supply of ribbon was coiled were weighed before and after the experiment, and the time during which the lamp was burning was accurately noted.

The strength of light was measured in the horizontal direction. A few determinations made at 33° (greater angles could not be used on account of the reflector) showed a decrease of the strength of the light of about 25 per cent.

TABLE V.

Number of ribbons.	Strength of light in normal candles.		Without reflector.		Hourly consumption of ribbon per 100 candles.
	Without reflector.	With reflector.	Candles per ribbon.	Consumption of magnesium per hour-ribbon.	
				grammes.	grammes.
1	150	3,200	150	16·7	11·14
2	237	5,880	118·7	16·7	14·10
4	450	8,000	112·5	16·7	14·80
6	700	11,300	117	16·7	14·15
8	950	17,000	119	16·7	14·03

The strength of light obtained per ribbon is therefore greatest when only one ribbon is burning; it sinks as soon as a second is introduced, but remains then approximately constant whether two or eight ribbons are in use. The somewhat abnormal result obtained with four ribbons is probably due to an experimental error.

The price of magnesium ribbon is at present 45s. per kilo. If the lamp burns with eight ribbons, it consumes hourly 134 grammes magnesium. If we disregard the first price of the lamp, it costs 6s. per hour burning, and 100 normal candles measured without reflector cost hourly $\frac{6.3}{100}$ of 1s.

The lamp examined pushes forward hourly 32 metres of each ribbon. This speed appears to be too great and can be decidedly reduced without reducing the strength of light of the lamp. Some of more recent construction push forward only 24 metres hourly. It appears also that the price of magnesium will shortly be reduced to 30s. per kilo. Hence an eight-ribbon lamp would consume hourly 100 grammes of magnesium, at the price of 3s., and the hourly cost of 100 normal candles would be only $\frac{3.2}{100}$s.

But even this price is still much too high to admit of the magnesium light competing with the electric light or with gas. The natural sphere of the magnesium light is different. It will be used wherever an intense light is demanded for a short time and where gas piping and electric installations are not at hand. For such purposes magnesium is the cheapest source of light. The magnesium light is readily portable, and can be kindled at any moment by means of a match and as quickly again extinguished.

It is thus suited for military purposes, for luminous effects in theatres, in photography, in nightly building operations of short duration, in ships, &c.

Lamps have also been recently constructed arranged for burning several hours (during which the mechanism does not need to be wound up again), and the greatest intensity of light is thrown, not horizontally but downwards. Such burners are already in use for lighting up large halls, &c.

There is no need in electrotechnics to fear the competition of the magnesium light, but one should rather seek to improve the preparation of this metal.—*Centralblatt für Elektrotechnik.*

ON PHOTOMETRY OF THE GLOW LAMP.*

By Captain ABNEY, R.E., F.R.S., and Major-General FESTING, R.E., F.R.S.

IN a paper which we read before the Royal Society ("Roy. Soc. Proc.," No. 232, 1884) it was shown when a carbon filament or a platinum wire in vacuo was gradually raised in temperature, that the different rays in the visible and invisible regions of the spectrum followed a law governing their intensity.

In the dark region of the spectrum (below the red) if the abscissæ to a curve represented watts (current and potential), and the ordinates the intensity of the ray under consideration, the curve so formed was hyperbolic, approaching more nearly to the parabolic form as the red was approached. In the visible spectrum the parabolic curve was actually reached, the vertices of the parabolas moving along the axis of abscissæ, the shift being greater the more refrangible the rays under consideration. This implied that until a certain number of watts had been expended the ray was absent. Further, we had shown in the *Philosophical Magazine* for September, 1883, that when measured by a thermopile,

$$\text{total radiation} \propto (\text{watts} - \text{constant}).$$

In the visible radiation of an incandescent filament in a glow lamp we are only dealing, however, with a small portion of the radiation, and therefore could not expect it to follow such a simple law as that which governs total radiation. It appeared probable, however, that as the intensity of any individual ray in this part of the spectrum increased parabolically, the sum of all the visible rays ought also to follow very closely the same form of curve, the vertex of such parabola lying at some point in the axis of abscissæ between the vertices of the parabolas of the extreme visible rays. It likewise appeared probable that when the rays of extreme refrangibility were absent or in defect, as is the case when the filament is red hot, the parabola would fail to represent the intensity of visible radiation.

In the communication we have already referred to one example of the applicability of the parabolic formula was given, for white light, but by itself it was hardly conclusive. We, therefore, conducted a series of experiments to ascertain if our anticipations were correct.

An incandescence lamp was selected as a standard lamp, through which a fixed current was maintained. This we used instead of a standard candle or other variable light. We then selected a second similar lamp, of which to measure the light when currents of various strengths were passed through it.

The shadow and grease-spot methods were both experimented with, the former being perhaps the most exact. Whichever method is, however, employed, it was inexpedient to move either lamp towards or from the source, or to vary the distance of the source from the lamp, as the carbon filaments show more or less illuminating surface to the screen according as they are close or distant from it. It therefore became necessary to adopt some other plan for altering the intensity of the light falling on the source from the comparison lamp.

In the Rumford (shadow) method, fig. 1 will give the general idea of the arrangements.

The shadows cast by the rod, D, from the two sources of light, were made just to touch each other, on the white screen, S, S, and to fall within a rectangle cut out of black paper, which deadened the light on the rest of the screen. Each lamp (L_I and L_{II}) was in connection with an ampèremeter and voltmeter (A_I, A_{II} and V_I, V_{II}). In front of L_I (the standard lamp) was placed an electromotor which caused a pair of sectors of variable aperture to rotate between it and the screen.

Evidently two methods are open to equalise the illumination of the screen from each source:—

1st. Cutting off more or less light from L_I.

2nd. Varying the current in L_{II} by means of the variable resistance in the circuit.

The first plan necessitates the opening and closing of the sectors whilst rotating, and the second the alteration of the resistance, &c., at will. Whichever method was adopted, the lamp, L_I, was brought to a bright yellow glow, and the lamp, L_{II}, had a current passed through it which, when the minimum

* Read before the Royal Society, Thursday, December 8th, 1887

resistance was in circuit in B, produced a brilliant white light. Such intense heat the filament would not be able to stand for any considerable time.

When measurements were to be taken by the first plan the instrument shown in the annexed diagram, fig. 2, was employed. A pair of sectors, S (each of 90°), are mounted on a horizontal axis, a similar pair, S_1, are carried on a short sleeve, to which are

FIG. 1.

attached two horizontal pins, p, p, passing through holes in the flange, D, of another sleeve, C. A stud in this last engages with a screw thread of long pitch cut on the axis. A horizontal movement of C thus causes it, as well as the sectors, S_1, to rotate with reference to the axis and the other sectors (S), and therefore alters the aperture. This movement is given by means of a vertical lever engaging with the groove, k on C, and which is actuated by the screw, B. The aperture can thus be varied between 0° and 180°, whether the instrument be in motion or at rest. The instrument has been described at length, as it varies in some particulars from previous ones, having been made under our own supervision. The edge of S is graduated into degrees so that the amount of aperture is at once known.

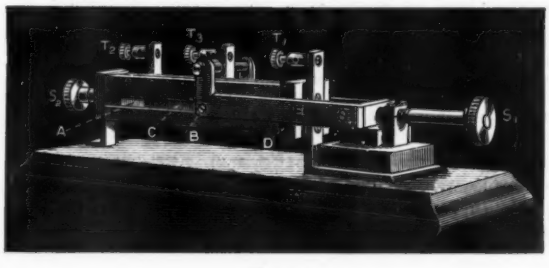


FIG. 2.

A certain current is passed through L_{II}, which is noted, and the sectors opened or closed till the shadows cast by the rod appear equally luminous. The motor is stopped and the aperture read off. Three or four readings for each current passing through L_{II} are taken, and then the current is altered, and a new set of three or four readings made. The current is altered so that the light from L_{II} varies from extreme brightness to a dull red.

By the other plan the sectors shown in fig. 2 are detached from the motor, and card discs placed on A. A resistance, R, fig. 3, has now to vary to bring the light equal to the standard light where the discs with known apertures are rotating. At first for the resistance we used a non-conducting tube, in which about forty spherical pellets of hard carbon were inserted. At one end of the latter was a brass plate to which one terminal of the battery was attached, and at the other a screw was inserted, which was attached to the other terminal of the battery through the lamp. This screw pressed the pellets together to any required degree, diminishing the resistance, or increasing it as occasion required. This answered fairly well, but not so well as would be desired, as the response to the screw was somewhat sluggish. Mr. Varley supplied us with one of his carbonised cloth resistances, which consists essentially of a series of square pieces of carbonised cloth more or less in contact. The figure represents the one we had made for us. The carbonised cloth is represented by C, fig. 3, which fills the whole length from A to D when loosely packed. At B is a plate to which T_3 is attached, and which can be separated more or less from a fixed metal plate to which T_1 is connected by the arm E, which is moved by the screw, S_1. At A is an insulated block carrying another plate to which T_2 is attached, and A can be carried backwards or forwards by means of the screw, S_2. For some purposes the main current can be brought in at T_3, and leads be taken from T_2 and T_1, thus forming part of a Wheatstone bridge. When only one resistance has to be inserted, T_1 and T_3, T_1 and T_2, or T_1 and T_3 may be used for connecting on to the leads with one pole of the battery and the ampère-meter. It was in this way the resistance was used in the case in point. The lamp, L_{II}, by the use of this could be raised from black heat to bright white, and a small turn of the screw altered the resistance very considerably. We used two sets of sectors; one pair enabled us to use an aperture from 135° to 90°, and the other pair from 90° to 0°. The light from L_I was diminished by the first pair of sectors being placed on A (fig. 2), the current ∝ potential being noted. The resistance of the current passing through L_2 was then altered till the illumination of the two shadows on the screen appeared equal, the screw, S (fig. 3), being turned backwards and forwards, first one shadow and then the other being made to appear too dark. By diminishing the oscillations the neutral point can be very readily arrived at, even though the colours of the lights may be very different (see Bakerian Lecture, 1886, "Colour Photometry," by the authors). The readings of V_{II} and A_{II} were then read and noted. The apertures of the sectors were altered, and the same operations gone through. From observations thus made the curves were constructed, enabling the theory propounded to be tested.

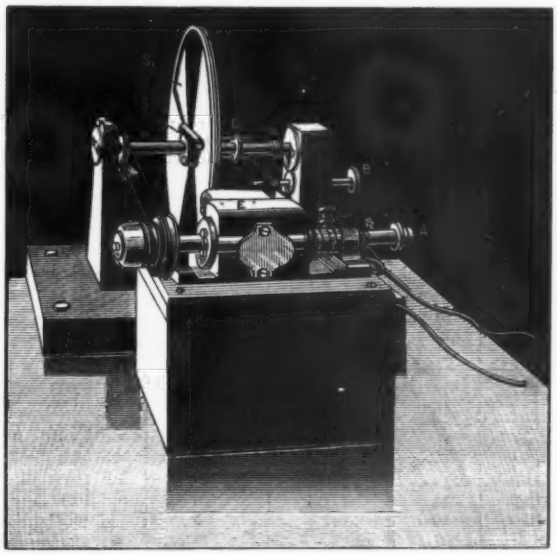


FIG. 3.

The grease-spot plan of photometry was arranged in a somewhat similar manner, L_{II} being on the opposite side of the screen, S, S, and the rod being abolished. In this method the room has to be dark so as to admit of no reflection. At first we were not prepared for any great exactitude with it, but finally we came to the conclusion that it was very reliable, a conclusion that Mr. W. H. Preece* came to when he constructed his photometric arrangements.

Having described the arrangements for taking the measurements it remains to give the conclusions at which we arrived after making a large number of experiments.

Let w be the power,
c ,, current,
p ,, potential,
y ,, intensity of light;

all other letters being constants.

In order for the curve of intensity to be parabolic

$$\text{(i.)}\quad w - m = n\sqrt{y},$$

m being the number of watts at which the vertex of the parabol lies.

From the equations given in the paper already referred ("Phil. Mag.," September, 1883), where—

$$c = a\,p + b\,p^{3\cdot2}$$

the above equation (i) may be written—

$$p^2\,(a + b\,p^{\frac{1}{2}}) - m = n\sqrt{y};$$

when p is fairly large this becomes—

$$\text{(ii)}\quad p^2 - h = k\sqrt{y} \text{ approximately.}$$

* "Roy. Soc. Proc.," vol. 36, 1884, p. 270.

Similarly it may be shown that—

(iii) $c^2 - s = t\sqrt{y}$ approximately.

Tables I. and II. will show the application of (i).

TABLE I.

A Woodhouse and Rawson lamp, changing the resistance and reading current and potential.

C.	P.	Power.	Aperture of disc.	Calculated aperture shadow.	Calculated aperture grease-spot.*
13·4	38·0	509·2	180	180·23	181·6
12·75	36·1	460·3	135	135·20	134·2
12·5	35·6	443·8	120	121·44	120·0
12·3	35·5	430·5	110	110·95	109·4
12·2	34·7	423·3	105	105·47	105·5
11·9	33·8	402·2	90	90·11	91·1
11·7	33·1	387·3	80	79·99	80·1
11·5	32·5	373·7	70	70·34	71·2
11·2	31·7	353·9	60	60·20	61·3
10·9	30·75	335·2	50	49·40	48·7
10·6	29·9	316·9	40	40·42	39·8
10·2	28·8	293·9	30	30·11	29·7
9·65	27·55	265·4	20	20·07	19·5
9·35	26·7	249·6	15	15·07	15·0
9·0	25·6	230·4	10	10·09	
8·4	24·2	203·3	5	4·75	

$m = 144.$ $n = 27·2$

* This column shows results given by the grease-spot method. The watts are not given, but merely the results, to enable a comparison to be made between the accuracy of the two methods.

TABLE II.

Swan lamp-light measured by changing the resistance and reading current and potential.

C.	P.	Power.	Aperture of disc.	Calculated aperture.
23·2	24·2	562·4	180	180·63
22·0	22·2	488·4	133*	132·71
21·6	21·6	466·6	120	119·89
21·4	21·4	458·0	115	114·91
20·6	19·9	410·0	90	89·14
20·2	19·2	387·8	79*	78·68
19·7	18·7	368·4	70	69·88
19·2	18·0	345·8	60	60·37
18·6	17·2	320·0	50	50·00
17·9	16·3	291·8	40	40·25
17·1	15·3	261·6	30	30·8
15·9	13·8	220·4	20	19·98
14·3	12·0	171·6	10	10·11
13·0	10·6	137·8	5	5·29

$m = 50·52$ $n = 38·0$

* In these two the sectors were supposed to be set at 135 and 80 respectively, but after the set had been taken and the sectors stopped it was found they read as in the table.

Table III. shows the readings in full of one set of observations.

Table IV. is an example of measuring by using known currents and cutting off more or less of the comparison light by the sectors. The observations have been given in full to show the deviation of individual observations from the mean.

TABLE IV.

C.	P.	Power.	Aperture of discs to balance light.	Mean observed aperture.	Calculated aperture.
7·9	28·1	222	90*	90	91·2
7·75	27·4	212	81, 81, 80	80·7	80·6
7·6	26·8	204	72·5, 72·5, 72·5	72·5	72·5
7·25	25·5	185	56·5, 56, 56·0, 55, 55·5	55·8	55·6
7·00	24·8	174	46·5, 47, 46·5, 45·5	46·4	46·6
6·7	23·8	159	37, 35, 36, 36	36·0	36·0
6·25	22·2	139	23, 24, 23·5, 24	23·8	23·6
5·85	20·6	120·5	14·15, 15, 14·5, 14	14·5	14·6
5·7	20·1	114	11·75, 11·75, 11·75	11·75	11·75
5·4	19·1	102	8, 8, 7·5, 8, 7·5	7·6	7·7
5·3	18·7	99	6·5, 6·5, 6·5, 7	6·6	6·8

$m = 53.$ $n = 17·7.$

* The light was fixed so as to balance as nearly as possible when the sectors were at their full aperture.

The foregoing examples will give an idea of the accuracy with which measurements may be made by either method, and of the exactness with which the parabolic curve is followed. It seems that the photometry of incandescence lamps may be well carried out by measuring the watts. It may be objected that each observation requires readings of the galvanometers, but this is avoided by the use of formula given in the beginning of this paper. Two observations of current and potential enable the constants to be calculated, and after that one galvanometer alone need be used; by preference that one giving comparative volts. The current is calculated from such a reading and subsequently the watts.

(To be continued.)

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A.

(*Continued from page* 590.)

In 1881, Mr. Rankin Kennedy† prepared a pump for exhausting lamps, going back in principle to that of Baader. Mercury is passed down a supply tube, s (fig. 16) and rises with the pump-head, expelling the air through a valve, v. Then a three-way eject tap, E, at the bottom is turned, cutting off communication with s, and allowing all the mercury in the pump-head to run out into a basin below. The lamp, or other vessel, B, to be exhausted, is joined in through an aperture at the top of the pump-head by means of a tube passing in through an India-rubber cork, c, and sealed above by a mercury joint. This tube is also supplied with an automatic valve, *v*, at its lower end, to allow it and the exhausted lamp to be removed from the pump, in order to seal it off. A similar device had also been described by Akester. Akester's pump ‡ closely resembled that of Lane-Fox; but in it the raising and lowering of the supply vessel was obviated by using, at the bottom of the pump-

* Read before the Society of Arts, Wednesday, November 23rd.

† Kennedy. Specification of Patent 5,524, of 1881. See also Dredge's "Electric Illumination," ii. p. ccxxxii.

‡ Akester. See Specification of Patents 4,458, of 1881, and 2,519, of 1882.

TABLE III.

Current.					Potential.					Aperture.		
Readings.				Mean.	Readings.				Mean.	Power.	Calculated.	Set on the sector.
1	2	3	4		1	2	3	4				
19·3	19·2	19·3	19·3	19·3	11·4	11·5	11·4	11·4	11·4	220	180	180
18·5	18·5	18·5	...	18·5	10·8	10·85	10·75	...	10·8	200	135·5	135
17·1	17·1	17·0	17·1	17·1	10·3	10·3	10·3	10·3	10·3	176	89·5	90
16·8	16·8	16·8	16·7	16·8	10·1	10·1	10·1	10·1	10·1	170	79·6	80
16·5	16·4	16·5	...	16·5	9 9	10	9·9	...	9·9	163	71·7	70
16·1	16·1	...	...	16·1	9·75	9·75	...	...	9·75	157	59·9	60
15·6	15·7	15·6	15·6	15·6	9·6	9·5	9·5	9·6	9·55	149	49·2	50
15·1	15·0	15·2	15	15·1	9·3	9·3	9·5	9·2	9·4	142	40·7	40
14·5	14·5	14·5	...	14·5	9·1	9·1	9·0	...	9·1	132	30·0	30
13·7	13·65	13·7	13·7	13·7	8·7	8·7	8·65	8·7	8·7	119	18·7	20
12·2	12·2	12·2	...	12·2	7·9	7·9	7·9	7·9	7·9	96·5	5·6	10
10·5	10·5	10·6	...	10·6	7·3	7·1	7·2	...	7·2	76·3	0·14	5

$m = 71·5.$ $n = 11·04.$

shaft, a three-way tap, enabling the barometric column to be placed alternately in communication with a supply cistern placed at a high level, and with a return pipe through which the descending mercury flowed away at a lower level, to be again pumped up to the high level by a mechanical pump.

FIG. 16.—KENNEDY'S PUMP.

Another way of raising and lowering the mercury in the pump, which also dispensed with flexible tubing, was suggested by Rock.* (A similar device was suggested by Mile in 1830). The pump-head and barometric column are formed by a single straight cylindrical tube, about 100 centimetres long, 10 centimetres in

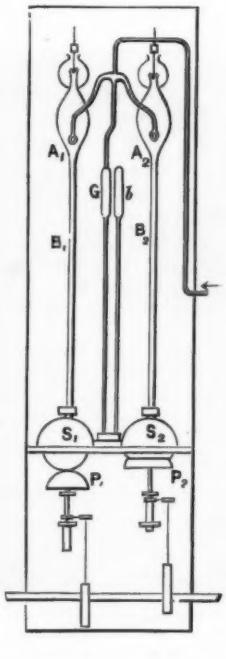


FIG. 17.—GARDINER'S DOUBLE PUMP.

internal diameter of glass, and 1 centimetre in thickness. It is open at the bottom, but closed in and furnished with the usual three-way tap at the top. Outside it is a second, slightly longer, tube, having an internal diameter of 12·6 centimetres. This—the supply vessel—is closed at the bottom, and can be raised or lowered mechanically. If the outer one, filled with quicksilver, is raised, the liquid forces its way up the inner tube, driving the air before it, through the three-way trap. When it is lowered, the mercury remains inside, to a height which will never exceed 76 centimetres above the level of the mercury in the outer tube, the space above being left vacuous. The inventor claims that this construction is less liable to give trouble than the usual form. Cruto* has used a somewhat similar device, but with sulphuric acid instead of mercury in the pump. To obviate having to work with a pump shaft 20 feet long, he adopted the device of an auxiliary exhaust pump. Narr† has described a simple pump on Jolly's plan, but having steel taps, the pump head of glass having united above and below to the working parts by carefully ground and lightly greased steel unions, clamped together by screws. By reason of its strength, this construction seems to be preferable in cases where very high vacua are not required.

Double-action pumps have been suggested by various persons. Kemp's pump (Fig. 8) was of this class, so is one by Serravalle,‡ in which there are two supply-vessels, so arranged that while one rises the other descends; two separate pump-heads, with two three way taps automatically opened and shut; and two exhaust tubes uniting into one. Another double pump, by Gardiner,§ depicted in Fig. 17, is worked mechanically from a rotating shaft. Two eccentrics drive alternately up and down two hemispherical pistons, P_1, and P_2, which press in the flexible hemispherical bottoms of the two supply-vessels. The valves of this pump are all automatic, as in Kemp's pump. It is provided with a barometric gauge, G, and a comparison barometer, *b*. This pump was in use for some time at the Gülcher Company's works at Battersea.

SUB-CLASS Ia.—SHORTENED UPWARD-DRIVING PUMPS.

The length of the pump-shaft in the preceding cases being necessarily equal to that of the barometric column, renders all these forms of apparatus more or less unwieldy. Although a column of mercury 76 centimetres high is a necessity for working between vacuum within and atmospheric pressure without, no such length is required when working between vacuum and a reduced pressure. In fact, the length of the pump may be shortend by reducing the pressure of the air above the surface of the mercury in the supply vessel, in all pumps of Class I. and Class II. The first suggestion

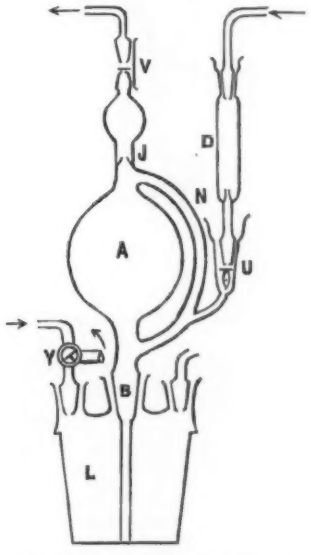


FIG. 18.—SCHULLER'S PUMP.

for shortening the pump came from the Rev. Professor Robinson,‖ in 1864, and was almost immediately followed by one from Professor Poggendorff.¶ In these apparatus a common air-pump worked by hand was used to produce a partial vacuum. The pump-shaft was quite short, and ended in an auxiliary chamber, closed at the top, but having a tap communicating either with the auxiliary pump or with the outer air. The three-way tap above the pump-head also opened into a tube which could be made to

* Rock. "Wied. Beibl," vii., 790, 1883.

* Cruto. Specification of Patent, 1895 of 1882.

† Narr. Ueber eine Abänderung der Jolly'schen Quecksilberluftpumpe. "Wied. Annalen," 542, 1885.

‡ Serravalle. "Riv. Scient. Industr.," xiv., 401, 1882; also "Wied. Beibl," vii., 490, 1883.

§ Gardiner. See "La Lumière Electrique," xiii., 219, 1884.

‖ T. R. Robinson. "Description of a New Mercurial Gasometer and Air-pump. "Proc. Roy. Soc.," xiii., 321, 1864. *Phil. Mag.*, xxviii., 235, Sept. 1864.

¶ Poggendorff. "Pogg. Ann.," cxxv., 151, 1865. See also Müller-Pouillet's "Physik" (1876), i., 233.

communicate either with the auxiliary pump or with the outer air. To fill the pump-head with mercury, air was admitted to the auxiliary chamber, whilst at the same time the auxiliary pump was applied at the top to suck the mercury into the pump-head. The three-way tap being then turned to put the pump-head into the vessel to be exhausted, the auxiliary pump was used to reduce the pressure in the auxiliary chamber, causing the mercury in the pump-head to fall, the height of the column representing always the difference between the pressure in the pump-head and that in the chamber.

Several later experimenters have adopted this device of applying an auxiliary pump to shorten the vacuum pump; and as we shall see, the device is applicable to each of the three main classes of pumps. Dr. F. Neesen,* whose more recent pump is described later, adopted this device in 1878. At that date he was employing a shortened Geissler pump, to which, independently of Mitscherlich, he had applied an automatic exit-valve above the pump-head. He had also introduced another notable improvement, namely, a side-tube, connecting the exhaust-tube from a point a little beyond where it branched off from the pump-shaft to a point above the pump-head below the automatic valve. Such a side-tube, marked N in the Figs. 18 and 33, prevents the fracture of the top of the pump-head by air bubbles suddenly rising through the mercury in the barometric column.

Schuller,† in 1881, described another shortened pump, with numerous carefully considered details, and a curious automatic method of operating, which, however, need not here be described. Fig. 18 shows Schuller's pump. V and U are automatic valves consisting of small pieces of flat glass, preferably triangular, which close the mouths of tubes that have been also carefully ground flat. In the valve V, shown in detail in Fig. 19, the weight of the small glass plate is partly sustained by the ring of mercury surrounding the tube end above which it lies.

FIG. 19.—DETAIL OF VALVE.

FIG. 20.—SCHULLER'S MERCURY VALVE.

Another feature of Schuller's pump is the valve J, situated in the tube between the pump-head and the upper valve V. This valve J, shown larger in Fig. 20, is composed wholly of mercury, which, during the descent of the body of liquid down the tube, forms, by virtue of its great surface-tension, a cap over the orifice three millimetres in diameter, which is here interposed. As in Geissler's later pumps, there is an auxiliary chamber, M, between V and J, in which a partial vacuum is formed, so that the residual air expelled from the pump-head is driven into an already exhausted space. The little vault of mercury over the aperture in J is able to withstand the difference of pressure between the partial vacuum above and the nearly perfect vacuum below it. At the commencement, a partial vacuum is made in the pump head, through the upper valve, by an auxiliary mechanical pump. A three-way tap, Y, suffices to put the space in the bottle, L, alternately into communication with the atmospheric air, and with a tube leading to an auxiliary mechanical air pump.

Another pump of this class, by Dittmar,‡ has simply two plain glass taps, one above, the other in the exhaust tube at the side of the pump head. It obviously could not give a good vacuum.

The most recent pump in this category appears to be that of M. A. Joannis.§ The ordinary three-way tap at the top of the pump head communicates with the open air; below, at the lower end of the pump shaft, is a closed vessel, communicating by another three-way tap with a water aspirator, and with a source of pressure by means of which the mercury is alternately raised and lowered.

* Neesen. "Wied. Ann." iii., 608, 1878; also Zeitschrift für Instrumentenkunde," ii., 287, 1882

† Alois Schuller. "Wied Ann.," iii., 528, 1881.

‡ Dittmar. See "Challenger Report: Physics and Chemistry," vol. I., 1884; plate 3.

§ Joannis. Modification de la machine pneumatique à mercure. "Ann. Chim. Phys." Series VI., xi., 285, 1887.

CLASS II.—DOWNWARD-DRIVING PUMPS.

The idea of expelling the residual air down a barometric column originated with Dr. Hermann Sprengel,* who in the year 1865 brought out the pump which is associated with his name. He had in the preceding years been studying the uses in the laboratory of the water trombe or aspirator, a much older instrument, used for some hundreds of years for delivering air under pressure. The theory of this ancient apparatus had already received the attention of Magnus,† and of Buff,‡ and Sprengel§ had himself devoted some attention to this method of furnishing air for the blow-pipe. It appears to have been an original idea with him to substitute falling mercury in the place of falling water, in order to extract gases by means of the vacuum produced above the column.

FIG. 21.—SPRENGEL'S PUMP (SIMPLE FORM).

The form of the original Sprengel pump is shown in figs. 21 and 22. The supply vessel, S, was, in this case, a funnel fixed at the top of the apparatus, from which the mercury was delivered at a steady rate through a narrow India-rubber tube, nipped by an adjustable pinch-cock. After passing this point it fell

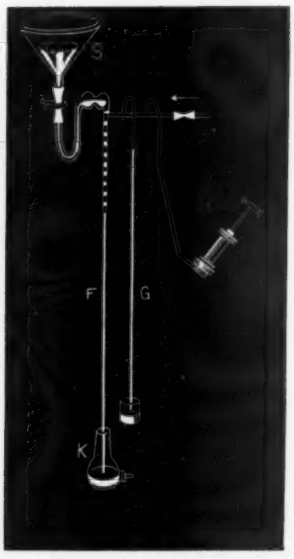


FIG. 22.—SPRENGEL'S PUMP (SECOND FORM).

in drops down a glass tube, F, of narrow bore, but having strong external walls, and known as the fall-tube. As it fell down this tube in drops, it swept out the air of the tube and the air which entered from the side, each drop acting as a piston to propel the

* Sprengel. "Journ. Chemical Soc.," Series II., iii., 9, 1865; see also Pogg. Ann.," cxxix., 564, 1865.

† Magnus. "Pogg. Ann.," lxxx., p. 32, 1850.

‡ Buff. "Ann. der Chem. und Pharm.," lxxix., 249, 1851.

§ Sprengel. "Pogg. Ann.," cxii., 634, 1861.

air below it. To secure this action, it is essential that the fall-tube should not be too wide. For rapid, partial exhaustions, an internal bore of 2 to 3 millimetres appears to be about the best size: for slower exhaustions, carried to the highest degree of rarefaction, a bore of 1·4 to 1·8 millimetres appears to be preferable.* During the first stages of the process of exhaustion, whilst yet there is a considerable amount of air in the fall-tube, the successive drops of mercury move separately down the tube, almost silently, being separated from one another by the intervening cushions of air, which, as they descend the tube, become more and more compressed. As a higher degree of rarefaction is attained there is no longer a sufficient cushion of air, the drops fall smartly through the vacuous space with a loud metallic clinking sound as they strike upon the top of the barometric column, which occupies the lower 30 inches or so of the fall-tube. At the bottom of the fall-tube the air and mercury enter a suitable vessel, K, from which, if desired, the air that has been carried down the fall-tube may be collected. The mercury which flows into K must be periodically collected and poured again into the supply funnel at the top. In the second form (fig. 22), a downward bend is inserted between the supply funnel and the point where the mercury begins to break away into drops. This bend leads to a small chamber, virtually the pump-head, from the end of which the mercury falls in drops. The flow is regulated by a pinch cock, which can be screwed up to nip, more or less tightly, a piece of flexible India-rubber tubing inserted in the supply tube. In this figure there is also shown a small mechanical air pump for rapidly producing the first partial exhaustion, and barometric gauge, *b*, to show the degree of rarefaction attained.

(To be continued.)

COMPOUND-WINDING DYNAMOS: BRUSH v. CROMPTON.

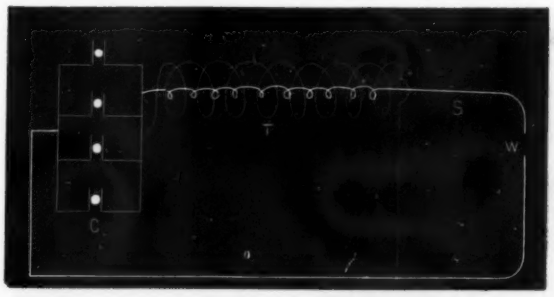
By S. ALFRED VARLEY.

(*Continued from page* 586.)

IN November, 1876, I made a rough brief note and a very rough diagrammatical sketch in my private note-book of the way the circuits were to be arranged and connected.

Had the case of Brush *v.* Crompton come to a hearing, my private note-book, as well as photographs taken from it, would have been produced in court, and I would have been prepared to swear that my machine was originally intended to be connected up, and was connected up, and worked as shown in the sketch.

A copy made from the rough sketch is shown in the following diagram :—



C represents the commutator made of four metal discs, mounted on but insulated from the axle of the machine, and divided into segments against which contact brushes press.

S represents the series wire wrapped on the cores of the field magnets.

T is the shunt wire of considerable resistance, the circuit of which is closed through the armature coils, as indicated in the sketch, and which is wrapped over the cores of the field magnets outside the series wire.

The space, W, represents the place where the external work is placed in the series circuit.

This commutator of mine is very suggestive of the commutator of Brush's machine. Both the Varley and Brush's commutators have this in common, that they cut the armature coils out of circuit at the neutral points successively during each revolution.

* See Gimingham. "Journ. Soc. Chem. Industry," III, 84, 1884.

I was somewhat before my time when I designed compound-winding, but that my patent was allowed to lapse, and that compound-winding was not further developed by me, arose simply from the want of financial support and encouragement on the part of my partners, who by the terms of our agreement were to find the necessary capital. I urged upon my partners at the time the unwisdom of not paying up the fees, telling them I had on more than one occasion had reason to regret allowing former patents to lapse. I should be very sorry, however, to seem to detract in any way from the credit due to those who, with the aid of financial resources I could not command, developed the germ I claim to have first introduced, and who carried it forward by a sort of process of evolution until a practically perfect self-regulating machine was arrived at. Those who followed me, and who after much labour and great expenditure succeeded in constructing the first machines which could really claim to be self-regulating, had the advantage over me that they were *not* before their time.

Great advances in every direction had already taken place when they may be said to have commenced taking the matter seriously in hand. Differential arc lamps, suggestive of compound-winding, had already come into general use; the possibility of successfully dividing the electric light had been demonstrated, and good glow lamps were also in the market, which made automatic self-regulation in the dynamo itself a crying want.

The claim now asserted by the Brush Corporation that automatic self-regulation was a special and distinguishing feature of Brush's machine was, I believe, an afterthought; and this view is confirmed, and to my mind *completely* demonstrated, both by a careful perusal and study of the lengthy specification in which Brush's invention is described, as well as by a reference to current electrical literature, in which the special features of Brush's machine are explained.

In the specification, which elaborately describes the minutest details, there is no mention whatever of automatic self-regulation, nor is there any reference to the characteristic feature of compound-wound dynamos, viz., that the force developed in the machine and the ratios of the energies passing through the two circuits rise and fall, and are affected by the quantity of work the machine is called upon to perform.

In Dredge's work on "Electrical Illumination," published in 1882, in one of the articles admittedly written by Conrad Cooke there is a most complete description of Brush's machine, taking up altogether 15 pages.

The very completeness of the description demonstrates that Mr. Cooke must have been put in possession of what Brush regarded as the leading and special features of his machine.

In this article Mr. Cooke describes minutely the different ways of exciting the field magnets of dynamos, and he explains the methods of Gramme, Siemens, Wilde, and others; but when he refers to Brush's invention he makes no reference to self-regulation or to compound-winding. At page 212, line 4, he describes the way Brush's machine is excited, and says :—"In the Brush generator, as well as in the ordinary Siemens direct current machine, the whole of the current from the armature is transmitted through the magnet coils, they forming with respect to the armature a portion of the external circuit." Now, if at the time the article quoted from was written it was considered that the distinctive feature of Brush's machine consisted in its being a series shunt machine, this certainly would have been pointed out to Mr. Cooke.

That Brush's machine was not then considered to be automatically self-regulating is demonstratively shown by the next sentence which appears in the article from which I have quoted, and which reads as follows :—"In several other systems, such as Siemens's alternating machine, &c., the field magnets of one or more generators are excited by the current from a special machine which has no other work to do, and in what

is known as the *shunt machine*, a special form of the *Siemens generator*, the magnet coils form a shunt circuit to the armature, by which arrangement the machine becomes to a *great extent its own regulator*."

The article I have quoted from I feel needs no comment as it speaks for itself, and therefore I pass on to Paget Higgs's "Transmission of Power," published in 1879. There is a chapter in this work devoted to describing Brush's machine. The way the magnets are wrapped is explained, but there is no suggestion throughout the whole of the book that Brush's machine possessed the property of self-regulation.

In "Dynamo-Electric Machinery," by Prof. Silvanus Thompson, in both editions published in 1884 and 1886, chapter 6, "On the Government of Dynamos," Thompson says, at page 94 (2nd edition) :—"The discovery of the method of rendering a dynamo machine automatically self-regulating when driven at a uniform speed is due to M. Marcel Deprez."

At page 93 he mentions several names as honourably associated in helping forward automatic self-regulation. Amongst these names there appear those of Messrs. Crompton and Kapp, but there is no mention or reference to the name of Brush. There is a foot-note, however, to page 101 :—"The invention of series and shunt-winding is claimed for several rivals ; Brush undoubtedly first used it, but whether with any knowledge of all its advantages is doubtful."

I have referred to the published writings of Messrs. Cooke, Higgs, and Thompson, because they have made affidavits on behalf of the Anglo-American Brush Corporation

It is almost needless to say the affidavits tell a different tale from that of these published writings. I would ask which of the two stories each of them tells is the true one. A cross examination in the witness box might have enlightened us.

Prof. Silvanus Thompson, your readers will be aware, has published letters protesting against stretching the clear meaning of patent specifications, and making them embrace and cover what was not in their authors' minds when they were drawn up. It is amusing to note how the scales would seem to have fallen from his eyes when he is retained in the interests of a powerful and wealthy corporation, and how, if his affidavit is to carry weight, Brush becomes suddenly lifted into being a far-seeing electrical genius whose claims to scientific consideration have somehow been hitherto sadly overlooked.

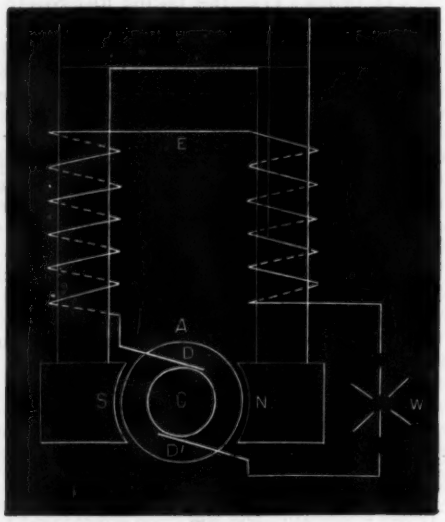


FIG. 1.
Wheatstone's No. 1 arrangement. A series wound dynamo.

I now return to my own patent and proceed to explain how it was that I simply described my invention, and, notwithstanding that I considered the series shunt arrangement an altogether new departure and therefore likely to prove valuable, why I did not, when the time arrived for drawing up the complete specification, make a special claim for it.

During the time my specification was being drawn up, I thought it advisable to consult the papers communicated to the Royal Society, in which Messrs. Siemens and Wheatstone announced their independent discoveries of the dynamo principle, and to enable me to do so my patent agent, Mr. Lloyd Wise, obtained for me the *Philosophical Magazine* in which they were published.

Wheatstone I found had described three methods of arranging the circuits.

The first was what is now known as a series dynamo, where there is only one circuit and the external work forms part of it.

In the second arrangement the external work formed part of the field magnet circuit as before, but there was also a shunt, or as Wheatstone termed it, a cross wire which was in circuit with the armature coils only.

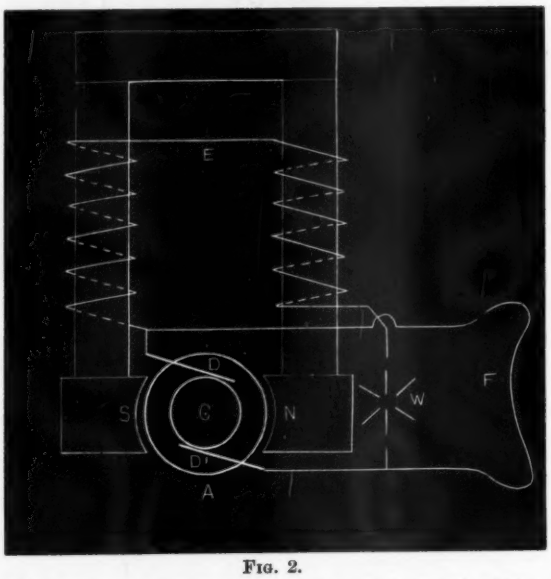


FIG. 2.
Wheatstone's No. 2 arrangement, with cross wire or shunt external to machine. A series wound dynamo with external shunt.

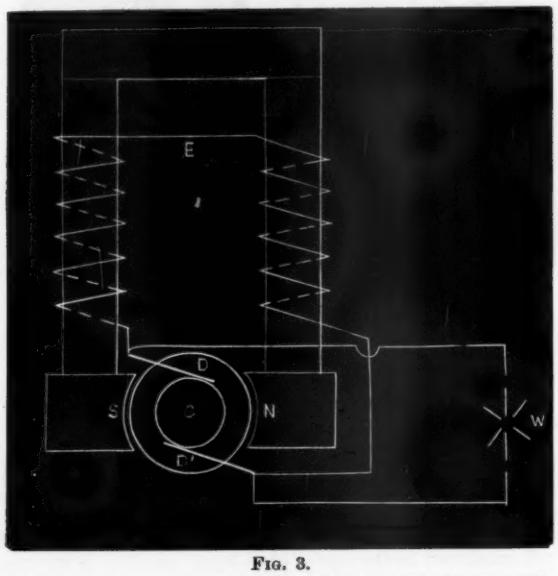


FIG. 3.
Wheatstone's No. 3 arrangement. The magnetising circuit in this arrangement is always closed through the armature coils and the work placed in the cross wire circuit. This machine is what is now known as a shunt dynamo.

The current developed in the armature coils with this arrangement divided itself through the two circuits in the ratios of their respective resistances, one part of the current passing through the magnetising coils and the external work, and the other part passing through the shunt circuit only where it did no useful work.

The third arrangement described was what is now known as a shunt dynamo, the coils which magnetised the magnets being closed through the armature coils only, and the external work being placed in the cross-wire or shunt circuit, and this third (*i.e.*, shunt dynamo arrangement) was found to give the best results.

In the same *Philosophical Magazine* I found another paper read at a later date before the Royal Society which came upon me as a surprise.

It was a communication from my brother, the late Mr. C. F. Varley, of which I had never been informed, and the title of it was "On certain points in the theory of the magneto machines of Wilde, Wheatstone and Siemens."

My original dynamo was completed in August, 1866, shown to my friends early in September, and provisionally protected in December, 1866.

Messrs. Wheatstone and Siemens's communications were read on February 14th, 1867, and that of C. F. Varley on March 16th, 1867.

My late brother was well aware of the existence of my earlier dynamo, but I found he had made no mention or reference to it in the paper communicated by him to the Royal Society. In C. F. Varley's paper it was stated that the shunt dynamo arrangement of Wheatstone prevented the formation of magnetic eddies in the magnets to a great extent, and that this was the reason of the greater efficiency observed. I found further that my late brother had made two suggestions, one of these being to place copper tubes over the magnet cores of Wheatstone's series arrangement, and the other to wrap Wheatsone's shunt or cross-wire circuit over the field magnets so as to utilise the energy developed in the cross-wire for increasing the magnetism of the field magnets instead of wasting it as Wheatstone had done. By way of parenthesis, I may mention that Brush, I believe, did in some of his machines use copper tubes as suggested by C. F. Varley.

To show more clearly Wheatstone's three arrangements and C. F. Varley's suggestions I annex drawings of them.

It was evident to me, from reading my late brother's paper, that he had quite another object in view than that which led me to devise my series shunt arrangement; but, at the same time, I could not overlook the fact that if the cross-wire of Wheatstone (instead of being outside the machine) were wrapped on the field magnets, and the work to be performed were placed in this circuit (which Wheatstone had already pointed out was the best place for it), a series shunt dynamo would be the result.

It therefore seemed to me that what C. F. Varley had suggested, combined with what Wheatstone had already done, might be considered as somewhat anticipating what I had independently worked out for another purpose.

Only those placed in a similar position can realise what my feelings were when I made this discovery. I consulted my patent agent, but he could only advise on what I told him, and naturally he recommended my claiming only that which I could be sure of.

Now a good many years before this my late brother had informed me, at a time when he was drawing up a specification he attached more than usual importance to, that his patent agent, the late Mr. Carpmael, had advised him to consult Mr. Grove, Q.C. (now Sir W. Grove, the judge), and the advice given him was to simply describe his invention and to leave all claims open.

Now past experience had taught me to consider that, under certain conditions, Grove's advice was the right one, for I had learned to recognise that new departures in the practical applications of science often proved to be the germs of further developments which one could not see at the time, and I considered those who *really* made new departures had some claim, at all events, on such developments.

I considered the matter from all points as well as I could, and in the end determined to leave the claim for series shunt-winding open; but it was not that I doubted that such a claim could be sustained, but because I was really afraid of what my brother might do. What I was most afraid of was that he might frighten my partners by threatening litigation. I do not want to say more than is necessary on a personal matter, but I feel the time has arrived when I must either assert what I consider to be my just claims or abandon them altogether, which I see no good reason for doing. The mischief which has been done to me

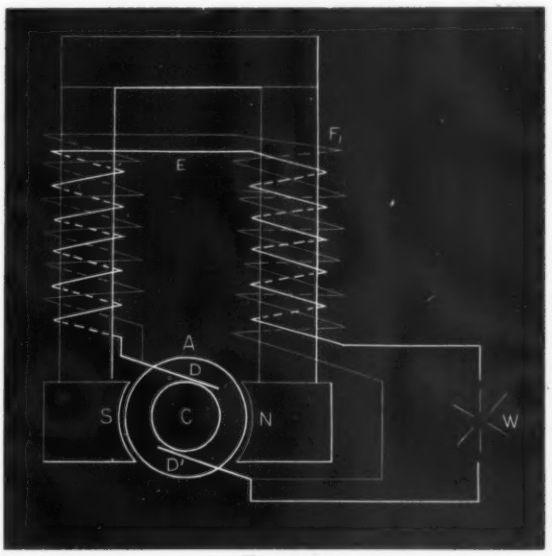


FIG. 4.

C. F. Varley's proposed modification of Wheatstone's No. 3 arrangement in which ths cross wire or shunt of Wheatstone was wrapped on the magnets forming a series circuit, the magnetising circuit as in Wheatstone's No. 3 arrangement being always closed through the armature coils. This suggested modification converts the shunt dynamo of Wheatstone (fig. 3) into what is now known as a compound wound machine.

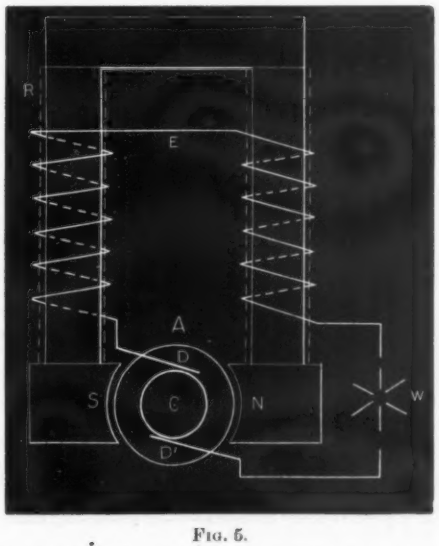


FIG. 5.

C. F. Varley's 2nd suggested modification of Wheatstone's dynamo in which the magnets (series wound) are encased with copper tubes.

Letters of Reference.—N, S, poles of field magnets between which the armature, A, revolves. C, commutator. D D¹, collector brushes. E, the circuit which magnetises the cores. F (fig. 2), cross wire or shunt. F¹ (fig. 4), series wire of C. F. Varley's suggested modification. R (fig. 5), copper tubes encasing magnets of C. F. Varley's 2nd suggested modification. W, external work circuit.

is in a sense irreparable. It has enabled more than one to shunt me, and, with a certain appearance of plausibility, to deny my claims as a discoverer. Some day I may have a bone to pick with Dr. Tyndall, who seemed to go deliberately and unnecessarily out of his way to do me an injustice; and, apparently, simply to ingratiate himself with the late Sir W. Siemens, who in *this* matter could not be fair, and went even further than Dr. Tyndall, for not very long before he died, in a lecture delivered before the Institution of Civil Engineers, but which was published in his lifetime, he stated that the communications which announced the independent discovery of the dynamo principle by Werner Siemens was read before the Royal Society in 1865, instead of, as was the case, in 1867.*

In both editions of Dr. Silvanus Thompson's treatise on dynamo-electric machinery my name is *absolutely* ignored in connection either with the discovery of the dynamo principle or its development. I feel this is an instance where I should be excused for using strong language; that I do not do so is only because there is no language I can command which would express adequately what I think.

In passing on to the affidavits made in the late case of Brush *v.* Crompton, I must ask your readers' consideration if I should seem somewhat discursive, for I feel it necessary before actually analysing them to make some general remarks on the subject of scientific evidence, of which, in more than one late case, we have had some curious experience. There has been a feeling growing upon me now for some little time that there is a necessity for a new strategy. It is seldom sufficient to act only on the defensive; decisive victories are obtained more often than not by flank marches, and by attacking the base of operations.

I experience the difficulty of my position, for I have now to deal with great reputations, and I should be exceedingly sorry if, in the remarks I find myself compelled to make, I may be considered to have said anything which might be construed as derogatory to the scientific profession as a whole; but it is no fault of mine if I am compelled to criticise the "tremendous" name of Sir William Thomson—yes, the truly tremendous name in *his own special* kingdom, which I am bold to say is not that of a special pleader in the law courts. I hope, however, my remarks will not be taken in any sense as personal, for I have always regarded it as one of the red letter periods of my life when I made his acquaintance, some little time before the Atlantic had been permanently bridged telegraphically, and when I acquired that reverence and respect for his attainments, which everybody brought into contact with him must feel. I was pleased also to find that it was then in my power to render some assistance (at *that* time *not* altogether unimportant), and for which I was specially thanked, and I appreciated those thanks none the less that they were conveyed with tact and delicacy through the medium of Mrs. Thomson.

I have also in my lifetime come in contact with several of our other more distinguished scientific professors, most of whom have passed away, and I have regarded them as ideal examples of

> Ingenuas dedicisse fideliter artes
> Emollit mores nec sinit esse feros.

Men who have passed their early manhood in college halls and surroundings devoted to culture, and eloquent of all that is great and good in the past.

Such persons are deservedly the honoured guests of society which turns only its better side towards them, and happily for themselves, they are often ignorant of how wicked the world really is; but if such people unfortunately fall into the hands of a clever company promoter, there is a danger of their becoming like clay in the hands of the potter, or perhaps rather as a work of art in wax before a fire. They remind one of some of those rare curious plants which require a special atmosphere to flourish in, and which in their own habitat it may be are priceless, but outside of which are really less valuable than an honest cabbage or good sound potato; nay, as ordinary food, they are often poisonous.

I was living in a country town when that letter, now historical, was published in the *Times*, in which Sir W. Thomson gave way to his scientific enthusiasm in the matter of storage batteries.

Previous to this letter appearing, I had done my little best by publishing a letter through the *Times* to try and mitigate as far as I was able the disastrous effects of that gas scare associated with the name of Edison.

The morning after the storage of force letter appeared, I met the rector, who buttonholed me, and was full of visions of an immediate supercession of steam locomotives. I reasoned with him and he listened, but what was I when weighed in the scale against the tremendous weight of Sir. W. Thomson? A little further on I met the curate, more excited even than the rector, and I could make no serious impresssion upon him.

A day or two later I met the doctor, who possessed gas shares, and was thinking of selling them, and he asked which of the electric companies I thought he ought to invest in. I advised holding on to the gas shares. Now I venture to think the mischief that letter inadvertently effected, when judiciously advertised and made the most of by the company promoter, was far reaching in its consequences, and many persons of refined traditions, gentle birth, and small means, were led away by it, and have every reason to regret its appearance.

Some of the scientific hair splittings which has, I am sorry to see, had influence in late electrical cases, remind me of such barren discussions as those in the middle ages as to how many angels could stand on a needle's point without touching one another. Angels

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* In 1877 a journalistic correspondence between the late Sir W. Siemens and myself took place. It arose out of letters from Dr. Siemens and myself, called forth by a leading article which appeared in *Engineering*. The greater part of this lengthy correspondence, which commenced in October and was not finished before December, would have been unnecessary could Dr. Siemens have brought himself to admit (what afterwards he practically had to do), that I had independently discovered the dynamo principle.

Just about the time this published correspondence commenced, a paper on "Recent improvements in dynamo-electric apparatus," by Messrs. Paget Higgs and Brittle, then in the employ of Messrs. Siemens Brothers, was announced to be read before the Institute of Civil Engineers, and a printed private copy of this paper, as is customary, was forwarded me.

I am not aware whether the journalistic correspondence had anything to do with the matter; but, as a matter of fact, the reading of the paper was adjourned until after the completion of the correspondence, when another edition of Higgs and Brittle's paper was sent out.

In the first edition of the paper my name was not mentioned, but in the second edition, the paper actually read, my name was referred to in conjunction with those of Wheatsone and Siemens as joint discoverers of the dynamo principle, but Dr. Tyndall was invited to take part in the discussion, and he spoke in that style which he has made peculiarly his own. He enlarged on the genius of and the world's indebtedness to "*my friend Sir W. Siemens*," and opened up the subject of my claims. He expressed his regret that if I had any real claims I had not read a paper before the Royal Society. He enlarged on his great impartiality and desire to do justice, and in the end mildly hinted that I was a pretender.

On January 17th, 1879, Dr. Tyndall gave a lecture on the electric light at the Royal Institution, and I exhibited in the library of the Institution my original dynamo, having previously advised Dr. Tyndall that I intended doing so.

He commenced his lecture by stating that he had been asked to give *some solid facts*, and in the course of his lecture he referred to my claims, and after treating his audience to a cloud of words having little pretension to any real logical sequence, but in which his knowledge as an artist and his mastery of the art of the dramatist were very conspicuous, he said he had been informed that a specification lodged in the patent office was a strictly private document, and that as I had not brought the matter at the time before any scientific societies, nor described it in any of the journals scientists (*i.e.*, scientific popes) acknowledged, I had no claims to be considered in any way to have discovered the dynamo principle.

The title of Dr. Siemens's lecture was "On Electrical Transmission and Storage of Power," and was delivered on March 15th, 1883. The date of his communication announcing Dr. Werner Siemens's discovery was referred to twice in the course of the lecture. See pages 62 and 63, "Practical Applications of Electricity," published by the Institution of Civil Engineers.

in the eyes of the learned of those days being, I suppose, the analogue of the ultimate indivisible immortal atoms, or centres of force of the present time.

It is easy for the scientific specialist to refine away almost anything, for the leading features of Nature are harmony and continuity; Nature objects to extremes, and her laws are confined within definite limits. There is apparently no such thing as absolute solidity, no such thing as absolute space, there is no body perfectly elastic and no substance absolutely inelastic; even the laws of friction do not hold good in extreme cases, and if gases be compressed the space they occupy is only directly as the force applied within certain defined limits, and when this has been reached the molecules aggregate themselves closer together on their own account, and then resist further compression.

But, nevertheless, there is a language of common sense, and the language of common sense I venture to think should be the language heard in our Law Courts, and glass in the language of common sense is elastic, and putty or lead are inelastic substances, and not elastic, as a judge was lately persuaded to believe by clever counsel, assisted by scientific special pleaders.

(To be continued.)

OBITUARY.

F. C. GUILLEAUME.

WE last week briefly announced the death of Mr. F. C. Guilleaume, the proprietor of the firm of Messrs. Felten & Guilleaume of Mülheim-on-the-Rhine, the well-known wire drawers, telegraph engineers and manufacturers. The deceased gentleman was born on the 30th December, 1834, and in 1865 succeeded to the sole proprietorship of the business, which, in consequence of his energetic management, has now become one of the largest, if not indeed the largest, of its kind. Amongst the many extensive operations which Mr. F. C. Guilleaume successfully carried out may be especially mentioned the German underground system of telegraphy, which was commenced in 1876, the first cable being a length of 105½ miles, from Berlin to Hallé. This proved so satisfactory that the Government subsequently decided to construct a complete network of underground telegraph cables, the total length being 3,390 miles, which for the most part were manufactured and laid by Messrs. Felten and Guilleaume. As some recognition of the services he had rendered to industry, Mr. F. C. Guilleaume was made Chevalier of the Legion of Honour by the French Republic. By the King of Prussia he was decorated with the "Order of the Crown," and also received the title "Councillor of Commerce." The deceased was possessed of deep penetration in commercial affairs, and the present prominent position of the firm is due solely to his restless energy and keen spirit of enterprise. The works at Mülheim find employment for upwards of 2,500 hands, and the deceased gentleman, while being foremost in the fierce struggle on the markets of the world, did not forget the comfort and welfare of his workmen, for whose benefit he invested large sums of money, and founded many provident institutions. The funeral, which took place on the 5th inst., was an imposing sight, and at the same time a touching tribute to the memory of the deceased, not only as an acknowledgement of his abilities and achievements, but also of the interest he had always manifested for the welfare of his workmen. By the death of Mr. Guilleaume industry has lost one of its most ardent promoters, and his name will long be remembered as amongst those who have always had at heart the real interest of mankind. The deceased leaves behind him a widow, three sons, and two daughters. The business will be taken over by the eldest son, Mr. Theodore Guilleaume, who has greatly assisted in the management for some years past.

NOTES.

The Electric Lighting of the Brussels Exhibition of 1888.—The lighting of this exhibition is to be equally divided between gas and electricity. Arrangements have been made to have the greatest possible number of systems represented. The principal English firms which have applied for spaces up to the present are the Gülcher Company, of London, Messrs. Bury, of Manchester, the Bernstein Company, the United Electrical Engineering Company, and the Anglo-American Brush Corporation, of London. The Thomson-Houston International Electric Company, of Boston will also participate in the work. The executive committee intends to provide a service of small electric tramways worked on the accumulator principle, each car carrying 10 or 14 persons. These will probably be provided and worked by the Jablochkoff Company, the Thomson-Houston Company, and Mr. Reckenzaun.

Domestic Electric Lighting.—The lighting of private buildings by electricity is, though it may be slowly, yet surely progressing, says the *Builder*. Some of the houses in Kensington Court are already lighted in this manner, and the electric current has now been extended to some houses in the neighbourhood of Palace Gate. The dull, dim light given by the gas supplied to London is inferior to that given by good mineral oil, and we shall be surprised if in a few years an enormous change in the domestic lighting of our large cities is not seen. It is contrary to all experience, adds our contemporary, that when Bond Street shops and Kensington Houses enjoy a bright, clear light, shops and houses elsewhere should be satisfied with an inferior light, which adds to the household expenses by the way in which it dirties the interior of buildings.

Electric Light and the Parcels Post.—On Wednesday evening last week the Electric Apparatus Company started lighting the Brighton parcel post mail by the electric light. The vans are fitted with three front lights and two inside lights for sorting. Some difficulty was met with in the jarring of the vehicle, but everything went very satisfactorily in the end. The bright light, we read, caused considerable attraction on the road, and the officials and driver were very much pleased with the power of the lamps. The installation was under the care of Mr. H. Bevis. The light will run for three journeys of nine hours each, and in the event of everything working well, it is said to be the intention to light all the Brighton mail coaches.

Shop Lighting in Glasgow.—Messrs. Wylie, Hill and Co., who have recently entered new premises in Buchanan Street, Glasgow, have there installed the electric light in the numerous departments of which their establishment consists. An Otto gas engine of 12 H.P. nominal supplies power for a Mather and Platt dynamo, which runs 200 Edison-Swan incandescent lamps of 16 C.P. Great taste has been shown in the fitting of the lighting arrangements, coloured glass shades and artistically finished electroliers being attractive features, and in addition there is a capitally arranged grotto with stalactite roof lit by the electric light.

Electric Lighting at Weston-super-Mare. — The Local Board for the district of Weston-super-Mare desires to receive tenders for lighting its district with electric light. Tenders to state price for lighting, providing, fixing, and keeping in thorough order and repair, all wires, posts, &c., connected with the lighting of 60 lights, 1,200 candle-power, averaging six hours per day, at per light per annum for 3, 5, and 7 years respectively; the same for seven hours; and the same for eight hours. Also (same number of lights and candle-power) *per hour* for the respective periods of 3, 5, and 7 years. Sealed tenders to be sent to Mr. W. Smith, Clerk, on or before the 19th instant.

Electric Lighting of Theatres.—The Empire Theatre is to be reopened on the 22nd. It has been entirely redecorated, and when finished will be one of the finest theatres in London. The whole of the brackets, chandeliers, &c., have been made for electricity, and manufactured by Messrs. Vaughan and Brown, in conjunction with Mr. Harry South, electrical engineer, who is laying down the whole of the plant, engines, &c.

Lectures on Electric Lighting.—On Monday Prof. Ewing, of University College, Dundee, brought his popular course of lectures on electric lighting to a close, the subject of the final lecture being the cost of electric lighting for factories and domestic purposes. Taking the case of a factory, where the necessary engine power was already provided, he said that the first cost of the whole electric plant, including dynamo, wiring, lamps, and fittings, was a little less than £2 per lamp, provided the number of lamps was over 200. He then considered in detail the cost of lighting a factory with 400 lamps. The first cost of the electric plant was £800, which represented an annual charge of, say, £88 on account of interest and depreciation. The current outlay for coal, oil, and lamp renewals was considered in detail, and shown to be about 2s. for each hour that the lamps were in use. If the lamps were only used for a small number of hours in the year the whole working cost was high, because the charge for interest and depreciation had to be spread over that small number of hours; but if the number of hours of use was large electricity was found to be much cheaper than gas. There was a particular number of hours of annual lighting which made the cost of electricity just equal to that of gas. This number was 425 hours. The lecturer went on to speak of the cost of domestic lighting, and pointed out that it was very great where each householder had to supply his own electricity. By co-operation, however, it might be reduced to a more moderate figure, though it remained, and apparently would remain, for some time dearer than gas. Particulars were given of the public installations in London, Brighton, Antwerp, Berlin, Hanover, Milan, Tours, and Vienna, where in the aggregate many thousands of lamps were in use. At these places the public were supplied with the electric light at a charge which was usually a little less than ½d. per lamp per hour. At the conclusion of the lecture Prof. Ewing expressed his gratification at the remarkable way in which the attendance had been maintained throughout the course. A hearty vote of thanks was accorded to the lecturer.

The Telephone in Western Australia.—After years of expectation Perth has at last a telephone exchange. Fremantle also has an exchange undergoing construction, and the two towns will shortly be in communication, to the great covenience of the inhabitants, more particularly perhaps the tradespeople, of each. The subscription is, for any radial distance not exceeding half a mile, £15 per annum, and for every additional quarter of a mile or fraction of a quarter, 25s. extra.

The Rating of Telephone Wires.—The Lancashire and Cheshire Telephonic Exchange Company appealed, at the Manchester City Sessions on Friday last, against the assessment made upon it by the overseers of the city. The question involved was as to whether the wires of the company constituted an hereditament under the meaning of the statute, and were thereby liable to be rated as such. After hearing the arguments of both sides, the Recorder said the question was partly one of law and partly one of fact—namely, what was the hereditament which was ratable? He was of opinion that the wires should be regarded as gas, water, and railways were, and that, whatever the principle was that guided those who had to make the valuations on such properties, it should be applied to the rating of this particular property. A consultation took place between the counsel engaged in the case, and it was ultimately stated that an arrangement had been come to, under which the appeal would be dismissed with costs. The Recorder thereupon dismissed the appeal.

Telephones in Great Britain.—The following is a table showing the order of the popularity of the telephone in 16 principal towns of the United Kingdom. Aberdeen stands at the top with a telephone to every 201 of the population, and London at the bottom with one to every 1,185. The annual tariff is given for each town:—

Town.	Telephones.	Population.	1 telephone to every	Tariff.
Aberdeen	521	105,000	201	£10
Perth	137	29,000	211	10
Inverness	76	17,500	218	10
Dundee	623	140,000	224	10
Glasgow	1,472	522,000	354	15
Liverpool	1,399	586,000	419	20
Manchester and Salford	1,293	588,000	457	20
Greenock	132	66,000	500	10
Blackburn	229	115,000	502	12
Belfast	439	221,000	502	15
Paisley	104	55,500	532	10
Nottingham, &c.	293	190,000	644	15
Edinburgh and Leith	394	280,000	711	15
Leeds, York, &c.	554	400,000	720	15
Birmingham, &c.	520	500,000	961	15
London	4,200	5,000,000	1,185	20

Progress of the Telephone in South Devon.—The continued growth of the Western Counties and South Wales Telephone Company's exchange system in the three towns of Plymouth, Devonport, and Stonehouse is noteworthy. The company opened its exchange in December, 1884, and now it has no less than 202 subscribers with an average of 830 calls per day. This marks a wonderful increase of business during the past twelve months, for in December, 1886, the subscribers numbered 127, and the average calls per day were 410. During the year ending November 30th last the number of messages which passed through the exchange reached the remarkable total of 436,776, an average of no less than 3,000 for each subscriber. The statistics of the Post Office exchange do not show so satisfactory a condition. Established in 1881, this exchange now only possesses a list of a dozen subscribers, with an average of about as many calls a day. Plympton, a village a few miles from Plymouth, is about to enjoy to the full the advantage of connection with the telephone. Some months ago the Post Office was, to the great inconvenience of a large number of the inhabitants, removed to a distant part of the village. Thereupon application was made to the Western Counties Company to connect Plympton with the Three Towns exchange system by means of a trunk line. The company promptly acceded, and is now engaged in erecting the line, which will be purely experimental, and which will cost a considerable amount. It will be completed by the New Year.

Telephones v. Speaking Tubes.—Telephones are now coming into use as a substitute for speaking tubes in large buildings. The Equitable Telephone Association, Limited, has just completed an installation of six instruments at 27, London Wall, whereby all the different floors of the warehouse are put in direct communication with one another and with the general and private offices. The same company has at present in hand a similar installation with 27 telephones in the new warehouse and offices of the Co-operative Wholesale Society, Limited, Leman Street, Whitechapel.

Personal.—Mr. H. M. Hull and Mr. J. E. Stewart, who have been for some years with Messrs. Woodhouse and Rawson, are starting business in partnership at Newark-on-Trent as electric light engineers and contractors.

We are requested by Mr. Alfred Slatter to state that he has retired from A. Slatter & Co., Limited, and that for the present his address is 27, Regent Street, S.W.

Theatre Lighting.—It has been decided in Madrid that no theatre is to be allowed to open its doors next winter unless it is lighted by electricity.

Electric Lighting in Germany.—Dr. von Stephan states that at the present time there are at least 15,000 arc lamps and 170,000 glow lamps in operation in Germany, which receive their light from 4,000 dynamos.

The Bradford Electric Lighting.—A lengthy and somewhat amusing correspondence has been going on in the Bradford *Observer* anent the action of the Bradford Corporation referred to in our other pages. Naturally, like doctors, the writers on the subject of electric lighting disagree, one gentleman declaring that no satisfactory meter exists, while others state that there are half a dozen excellent devices for measuring electrical supply already in the market. The matter of the projected purchase of Messrs. Schmidt, Douglas & Company's works is discussed *pro* and *con* with some degree of acrimony, and our provincial contemporary sensibly observes, "When contradiction is so gross at the outset, the need becomes manifest of two or three councillors who will take more than perfunctory interest in the enterprise, and see that it is carried well through."

Telegraph Line across the River Luan-ho.—The extension of the Chinese telegraph system has involved the crossing of several large rivers, a matter of no small difficulty, owing to the enormous dimensions of the summer floods. The river in question, whose ordinary width is about half-a-mile, is swollen by the rains to a breadth of more than eight miles, and quite recently a large village situated nearly five miles from the western bank was completely destroyed by the overflowing torrent. Heavy cables have been used for these crossings, but their lives have been of short duration, due partly to the *débris* brought down, partly to the constantly-changing river-bed. It was therefore decided to divert the landline some 19 miles, taking it to higher ground where the river was naturally more restricted as to its channel, and effect the crossing by means of a wire rope. The extremities of the rope at the position selected are respectively 447 and 737 feet above the level of the river, the distance to be spanned being 1,549 yards. The line is supported at either end by stout wooden posts some 14 feet high and 14 inches in diameter at the top. These posts are firmly stayed and guyed by steel ropes. In consequence of the exceedingly heavy strain it was found necessary to employ granite blocks about 4 feet in circumference as insulators. A similar wire rope crosses the river Kistna at Bezarrah, in the Madras Presidency, having a span of 1,690 yards; there are two across the Ganges with spans of 966 and 943 yards; the Hooghly is crossed by a line of 711 yards; and in the United States a wire rope of 666 yards crosses the Missouri. The Chinese aerial line is consequently the second longest. The wire rope was manufactured by Messrs. Siemens and Company, of London. It is composed of seven steel wires stranded, each wire 0·145 inch diameter.

Henley's Cable.—*La Lumière Electrique*, in referring to the sailing of the *Roddam* with the new cable for the West Indies, says of it:—"This is the first section of a French system connecting up South America, the establishment of which is being undertaken by the French Society of Submarine Telegraphs." Unfortunate West India and Panama Telegraph Company! It has taken the present directors 15 years to undo the evils created by their predecessors in only two, but these 15 years have been apparently all too short a space in which to acquire a due appreciation of their position.

The Government and the Cables.—A correspondent of the daily papers states that, in anticipation of the taking over of the submarine telegraphs, the postal authorities are already actively engaged in perfecting and improving the means of communication between the central offices in London and the shore end of the cable which crosses the Straits of Dover. The plans for the new arrangements have necessitated work to be carried out which will keep the staff very busily employed throughout the whole of next year, at the end of which period the cable will be taken over. During the last few winters some very serious delays have taken place in the transmission of messages owing to the damage occasioned to the wires through severe weather, and with a view to minimise the occurrence of these delays the postal authorities are having insulated wire placed in tubes underground at all notably weak points on the line between Dover and London. The wires which are connected with the cable at St. Margaret's Bay, and which have hitherto been run into Dover from the cliffs on poles, have all been placed in tubes in this way, and carried as far as the Dover General Post Office, through which Continental messages will be transmitted. Provision has been made for any increase of business by laying several additional wires. Although nothing definite has yet been fixed with regard to the rates for Press telegrams, it is stated that a comparatively liberal scale will be adopted, the extent of which, however, will principally depend upon the French Government authorities.

The Atlantic Cable Pool.—With reference to the rumours that a dispute had arisen between the companies which form the American "cable pool," and that the working arrangement between them was thereby threatened with dissolution, the Press Association has been requested by the secretaries of each of the companies mentioned—the Anglo-American, the Direct United States, and the Western Union Telegraph Companies—to state that there is no foundation whatever for the statement made with so much circumstantiality regarding their relations with each other. The only disagreement about the pool rates was with the Paris Company, but that was of over a year's standing, and had no reference to existing relations of the pool companies.

The International Cable Company.—A correspondent of the *Financial News* enquires what has become of the International Cable Company, of which he is a shareholder. He has applied to the secretary several times, and has always been informed that "something will be decided at the next board meeting." He thinks what ought to be decided is to wind up the company.

Cable Connection for Mauritius.—Lord Brassey, in a letter to the *Times* upon "Defences of Coaling Stations," says it is highly desirable that Mauritius should be connected by cable with the line of telegraph recently laid to the Cape along the Eastern shores of Africa.

Shot-Firing by Electricity.—Last month experiments in shot-firing by electricity were carried out at Ynyshir, in South Wales, the representatives of some 5,000 miners being among the spectators. These gentlemen unanimously passed a resolution cordially congratulating the proprietor and the manager of the Standard Colliery, Ynyshir, for having effected such an important reform, which would, if generally adopted, render a great additional protection to thousands of miners. An electric lamp carried by the manager came in for a great share of attention and praise.

Glasgow City Hall Lighting.—On Monday at the meeting of the Town Council it was resolved, as to the lighting of the Bazaar and City Hall, that the tender of Mr. R. Miller (Thomson-Houston system) should be accepted. One member asked whether the committee had satisfied themselves as to the safety of this system, as he was informed that it was not so safe as others, and remarked, "With some systems you could take both wires in the hand, but with this one it meant instant death." To this another member replied, "The wires are no' for takin' in the han's at all."

The Extended Electro-Metal Extracting, Refining, and Plating Company, Limited.—This company, to which reference was made in our issue of November 18th, has now issued its prospectus which will be found in our advertisement columns. The capital of the company is to be £150,000 in shares of £1 each, and we understand that the number to be taken by the shareholders of the original company is sufficient to guarantee that the new company will proceed to allotment.

Miners' Safety Lamps.—Mr. W. H. Preece, F.R.S., is announced to read a paper at the Royal Institution on Friday, February 10th, 1888, upon "Safety Lamps in Collieries."

The Manchester Postmastership.—It seems to be understood in St. Martin's-le-Grand, says a correspondent, that Mr. Hobson, Postmaster of Glasgow, will succeed the late Mr. Beaufort, who held the same post in Manchester, and that in turn Mr. Hobson will be succeeded by an energetic Scotsman who occupies an important position in the postal service in London, and who did a great deal of good work in connection with the transference of the telegraphs from the private companies to the Government.

Copper Wire.—Prices for copper wire have advanced another ½d. per lb., the present basis price being 10½d. per lb. for plain, sizes 0/20.

Electro-Deposition of Barnacles.—Mr. C. F. Henwood, at a recent meeting of the Royal United Service Institution, expressed the opinion that, by means of zinc-sheathing, applied so that the electro-positive zinc comes in contact with the electro-negative iron or steel, an electric or galvanic relation being thus established between them, the zinc would be perpetually dissolving away in an oxide, and carrying away with it the barnacles and other zoophytes, leaving a clean surface; and that iron or steel ships, so sheathed with zinc, might navigate the seas practically as free from fouling as our old copper-sheathed wooden ships.

The Manchester Jubilee Exhibition.—The buildings of this exhibition were put up for sale by auction on Wednesday at Manchester, the furniture and fittings having been disposed of during the earlier part of the week. The auctioneer announced that there was a reserve of £9,500, and that unless that price was forthcoming the buildings as a whole would be withdrawn and would be put up in separate lots. An offer was then made of £9,250, but beyond this the intending buyer would not go, though assured that the premises had been valued at £15,000. The sale of the separate lots was then commenced. The lots generally brought considerably less than the reserve put on them, in some instances the margin being as much as 30 per cent.

Fire in a Telegraph Works.—The heavy machinery department of Messrs. Johnson and Phillips, the well-known telegraph engineers, was burnt out early on Wednesday morning. The disaster will, however, in no way affect the carrying on of their general business.

To Our Correspondents.—We have several letters standing over till next week. If those desirous of using our columns would only respond to our frequent entreaties, that letters should reach us not later than Wednesday, much inconvenience would be avoided.

Loeb Chemical Electric Light Company.—With regard to the note which we published in our last issue respecting this company, Mr. H. Faraday writes:—"Your paragraph of December 9th rather anticipates proceedings in this matter. As one of the committee acting for the creditors, I can state that the offer made by the debenture holder has *not* as yet been accepted. As a tardy and enforced acknowledgment of the claims of the creditors, it seems very doubtful whether they will consider the offer as at all adequate."

The Society of Telegraph Engineers.—Until we can publish the papers of Dr. Fleming and Professors Ayrton and Perry together, we shall refrain from touching the subject dealt with by them.

Compound-Winding.—Mr. Sellon will understand Mr. Varley's reasons for not claiming compound-winding after he has perused that gentleman's contribution to this issue of the REVIEW. It is very evident that the experiments of Wheatstone and C. F. Varley, together with the results obtained by them, are but little known amongst that section of the electrical fraternity to which they should appeal most strongly. The statements contained in Mr. Varley's article may easily be verified by turning to the publications mentioned by him.

Adelaide Jubilee Exhibition.—Messrs. Woodhouse and Rawson, Limited, have been awarded the first order of merit for their exhibition of electrical fittings and appliances at the exhibition now being held at Adelaide.

Royal Society.—Dr. C. R. A. Wright, F.R.S., and Mr. C. Thompson, F.C.S., were announced to present to a meeting of the Royal Society on Thursday a note on the development of feeble currents by purely physical action, and on the oxidation under voltaic influences of metals not ordinarily regarded as spontaneously oxidisable; and at the same meeting Mr. Preece was to read a second paper on the heating effects of electric currents.

Ironclad Dynamos.—Mr. Rudolf Eickemeyer and Prof. Houston still put forward counter claims to the invention of the above in the New York *Electrical World*. Seeing that ironclad dynamos are not likely to come into use, we have our doubts as to whether the matter is worth the energy the disputants are expending in the discussion.

Electric Welding.—The *Street Railway Journal* publishes the description of a system of electric welding invented by a Mr. Ries, which has for its object the welding together in *situ* of railway metals so as to form continuous rails. If Mr. Ries is a railway engineer he ought to know better.

The Industrious Gas Meter—We take the following amusing description of the powers of the gas meter from our namesake across the water, in whose columns it appears over the signature "C.O.B."

> Oh, gas may escape, and gas may burst
> And vanish in noise and flame,
> But the meter's hand, in its quiet way,
> Goes travelling onward, day by day,
> And gets there just the same.

Physical Society of Glasgow University.—A meeting of the above society was held last night in James White's scientific instrument factory, Cambridge Street, Mr. Magnus Maclean, president, in the chair. Mr. Thomas Gray exhibited and described an improved form of the Gray-Milne seismograph. This is an apparatus designed to record the various motions of the earth at a point on its surface during the transit of an earthquake, together with the time at which the motions take place, and their period. The motions are recorded in ink on a band of paper in the form of three components, one vertical and two horizontal, at right angles to each other. The apparatus is capable of recording any number of successive earthquakes which may take place during a week without adjustment by the observer. At the same meeting Mr. T. A. B. Carver explained a quick method of photography, which has also the advantage of allowing prints to be taken by gaslight. During the remainder of the session a paper will be read on "The Electrolysis of Copper in Standardising Electrical Instruments," by Mr. A. W. Meikle, on January 27th; and Mr. T. Gray will describe apparatus for determining the horizontal component of the earth's magnetism on February 10th.

Central Station Lighting in Austria.—The central electric light station at Gastein is rapidly being pushed on, *Industries* states. There will be about 600 glow lamps of 16 C.P. distributed in various hotels and private houses, and 60 glow lamps of 20 C.P. erected for street lighting. In addition to these there will be a few arc lamps placed in prominent points. The general application of arc lamps for street lighting is inapplicable, on account of the irregularity of the streets. The motive power will be derived from a cascade formed by the river Gasteiner Ache, which is estimated to represent a total of 1,500 to 2,000 H.P. in falling water. The generating station will be placed in close proximity to this waterfall, and the ground for it had to be specially prepared. This was a very costly and laborious undertaking, involving the removal by blasting of about 450 cubic yards of solid rock. Motive power will be supplied by a Girard turbine of 125 H.P. running at 170 revolutions per minute, and calculated to consume 110 gallons of water per second with a fall of 82 feet. There will be four dynamos installed, each of 20 units capacity, and these will receive motion by belts from a horizontal shaft having four pulleys with friction clutches. Of these dynamos three will be at work simultaneously, and one will be kept in reserve. There will be three independent feeding circuits, two supplied with current at 110 volts, and the longer third circuit at 130 volts. The whole installation is being carried out by Messrs. B. Egger & Co., the dynamos being designed by Mr. F. Drexler, the engineer to the firm. All indoor wiring in the hotels and houses is already finished, and the erection of the poles for the mains and street lamps is now in progress.

Cash Carriers.—The Messrs. Blakeney, of Dundee, have completed the erection of electro-pneumatic tubes for cash-carrying purposes through the whole of their extensive premises in Whitehall Street. The Messrs. Blakeney consider that they will effect a saving of about £30 a year, as they will now be able to dispense with the whole of the cash boys, whom, under the old system, they were compelled to keep. The system was devised by Mr. William Blakeney.

Copyright in Catalogues.—A good trade catalogue is a valuable means towards that much desired end good business, and in most branches of trade there are certain firms who attain a prominent position by the devotion of time, trouble, and money to the production of a complete and useful guide to buyers. Having done this the compilers are sometimes wise enough to enter the publication at Stationers' Hall and so secure the copyright, but it is to be feared that occasionally when this precaution is neglected, rivals in trade, who may not be so conscientious as they should be, think it no robbery to copy page after page of descriptive matter in the unprotected lists of their competitors, and to apply it to their own manufactures. We recently came across a case of this kind where a catalogue issued a few years since was largely made use of in the compilation of a similar list by a firm in the same line of business. Now, firm No. 1 has re-issued its catalogue, and to any recipient of the two publications, though it would be readily seen that one was largely a copy of the other, it would be a puzzle to tell which was the original and which the copy. The moral of which is, if you take the trouble to have any originality about your trade catalogue, and succeed in making it valuable, do not neglect the proper means of fencing it from piracy, because, if you do, not only may your brain-work be appropriated by others, but you may also run the risk of being considered the copyist.

Lighting Tenders.—Tenders are invited for lighting the streets of Midhurst with gas, oil, or otherwise, for one year commencing on February 10th, 1888, for the lighting inspectors. Further particulars may be obtained of Mr. J. Austin, secretary, Midhurst, to whom tenders in writing are to be sent by the 26th inst.

The Construction of Iron Curtains for Theatres.—At a recent meeting of the Society of Civil Engineers, of Paris, an account was given of the system of M. E. Edoux. The curtain consists of a rigid structure of double T and V iron upon which is riveted, on the side of the audience, sheet-iron presenting a perfectly plane, smooth surface. This metallic table is guided in its movement by two vertical rods of round iron upon which glide with but little friction cast-iron sockets fixed on the frame of the curtain. The curtain is worked by means of two hydraulic elevators, each having a piston-rod working in a tight cylinder fitted with a stuffing box. The influx of water into the cylinder is regulated by electric action.

NEW COMPANIES REGISTERED.

Taylor and Tucker, Limited.—Capital, £20,000 in £1 shares. Objects: To take over the business of Messrs. Taylor and Tucker, of 41, Berwick Street, Soho, designers and manufacturers of art metal work, such business including the supplying of clubs, mansions, and other buildings with gas and electric light and fittings for the same, also electric and other bells and artistic work of every description in iron, brass, and copper, or other metals or materials. Signatories (with 1 share each), S. Johnson, 6, Sydney Villas, Bowes Park, N.; *G. E. Tucker, 49, Walterton Road, W.; *T. J. Woodrow, Wanstead; A. R. Smith, 6, Claydon's Terrace, Stratford; J. H. Woodrow, 347, Kingsland Road; J. S. Spence, 2, Aden Grove, Stoke Newington; *J. Salmon, Wanstead. The first directors are the signatories denoted by an asterisk and Mr. S. Wadham; qualfication, 100 preference shares or 200 ordinary shares. Mr. Tucker is appointed managing director for seven years. The remuneration of the ordinary directors will be £100 per annum. Registered 8th inst. by Russell Cooke, 2, New Inn, Strand. Registered office, 41, Berwick Street, Soho.

Nightingale Automatic Electrical Machine Company, Limited.—Capital: £5,000 in £1 shares. Objects: To acquire the inventions for which provisional protection has been obtained (Nos. 13,970 and 14,062, of 1887), for improvements in the mode and means employed for automatically administering electricity to the human frame, and for improvements in automatic electric apparatus. Signatories:—G. W. Pitt, 125, Camden Road, 60 shares; G. J. Smallman, 111, Brixton Hill, 100 shares; G. W. Milner, Atkins Road, Clapham Park, 100 shares; H. Rose, Stroud Green, 1 share; A. H. Lloyd, Nunhead Green, 1 share; R. E. Lloyd, Harrow-on-the-Hill, 1 share; J. Findlay, Penge, 1 share. The first directors are W. C. Gilles, of 29, Newgate Street, and Maurice Hart, 19 and 20, Old Bailey. Registered 8th inst. by H. Montague, 5 and 6, Bucklersbury. Registered office, 3, Queen Street, Cheapside.

Platinum Plating Company, Limited.—Capital: £60,000 in £1 shares. Objects: To acquire the invention for improvements in the deposition of platinum by electricity, for which letters patent No. 10,477, dated 16th August, 1886, were granted to Wm. Arthur Thoms. Signatories (with one share each): Major-General T. W. Mercer, 12, Duchess Street, Portland Place; H. Parminter, 27, Clement's Lane; T. C. Dixon, C.E., 55, Lee Park, S.E.; C. G. Hale, 26, Austin Friars; Capt. R. W. Shackel, Sevenoaks; P. Parminter, St. John's, S.E.; G. A. J. Macdonald, Charlton. The signatories are to appoint the first directors. Remuneration: Chairman, £300 per annum; each director £100 per annum. Registered 9th inst. by Hy. Kimber & Co., 79, Lombard Street.

Phonopore Syndicate Limited.—Capital: £90,000 in £1 shares. Objects: This company proposes to purchase letters patent and trade marks relating to improvements in telephony and telegraphs, and to manu-

facture electric batteries and other apparatus to be used in connection with the inventions to which the said letters patent, &c., relate. The signatories are: E. Churchill, 9, Gilbert Street, W.C; J. Cromar, 348, Munton Road, S.E.; P. Parminter, St. John's, S.E.; E. M. Dawe, Blomfield House, London Wall; A. Cunnew, 70, New North Road; S. R. Habben, 77, Coburg Road, S.E.; C. D. Kimber, West Hill, Putney. The signatories appoint the first committee of management. Qualification; 100 ordinary shares. Remuneration: £100 per annum each, with £50 additional for the chairman. Registered 10th inst. by Henry Kimber & Co., 79, Lombard Street.

Sunbeam Lamp Company, Limited.—Capital: £25,000 in £10 shares. Objects: To manufacture incandescent electric lamps, and to purchase certain processes from W. Clarke, A. H. Chapman, Hon. C. A. Parsons, and J. B. Furneaux, of Gateshead. Signatories (with one share each): *W. Clarke, A. H. Chapman, *T. Bowden, J. B. Furneaux, J. Edmundson, *The Hon. C. A. Parsons, and R. S. Watson, all of Gateshead and neighbourhood. The signatories denoted by an asterisk are the first directors. Qualification: £100 in shares or stock. Registered 13th inst. by Pattison, Wigg & Co., 11, Queen Victoria Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Magnetic Bell and Signal Company, Limited.—The statutory return of this company, made up to the 27th October, was filed on the 2nd inst. The nominal capital is £100,000 in £1 shares, but the only shares at present taken up are the seven subscribed for by the signatories to the Memorandum and Articles of Association. Registered office: 2, Victoria Mansions, S.W.

Bernstein Electric Lamp Company, Limited.—The annual return of this company was filed on the 12th inst. The nominal capital is £100,000 in £10 shares; 2,814 shares have been taken up and the full amount has been called thereon. The calls received amount to £9,140. 1,900 shares are considered fully paid.

CITY NOTES.

The Eastern Telegraph Company, Limited.—This company announces the payment, on January 14th next, of interest at the rate of 3s. per share on the preference shares of the company, less income tax, for the quarter ending December 31st, 1887, and an interim dividend of 2s. 6d. per share in respect of profit for the quarter ended September 30th, 1887, on the ordinary shares of the company, free of income tax.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 9th were £3,878, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ended December 9th amounted to £4,756.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

THE annual general meeting of this society was held on Thursday, December 8th, Sir CHARLES BRIGHT, President, in the Chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, the Secretary read the annual report of the Council as follows:—

During the past year the numbers of the Society had been increased by the election of 5 foreign members, 12 members, 66 associates, and 36 students, or a total of 119. Fourteen associates and 13 students had been proposed and were waiting election. The death roll included 4 foreign members, 10 members, and 10 associates, including the society's librarian, Mr. A. Frost. Seven foreign members, 10 members, and 14 associates had withdrawn their names from the Society. The Institution of Civil Engineers had with their usual liberality continued to allow to the Society the use of their lecture hall. During the session a large number of interesting papers had been read. The Society's premium of £10 had been awarded to Mr. A. E. Kenelly for his paper on the localisation of faults in submarine cables; the Paris Exhibition premium of £5 to Mr. W. E. Sumpner, for his paper on the determination of the coefficient of self-induction; and the Fahie premium of £5 to Mr. C. T. Fleetwood, for his paper on underground telegraphs. The committee on electrical nomenclature had been busy, but had not yet been able to draw up their report. The committee to consider the question of a national standardising laboratory had come to the conclusion that it would not be possible to carry out the idea at present. The fire risks committee had been re-appointed, and had nearly completed their revision of the 1883 rules. Particular satisfaction was felt at the large increase in the number of students, and the special meetings which had been held for the latter had proved very successful; the papers read were eligible for premiums. The subscription which had been started towards the Imperial Institute Fund had only proved partially successful, the amount subscribed not having exceeded £71. Towards the Telegraph Jubilee Fund, which was to be devoted to the improvement of the library of the society, the sum of £162 17s. 6d. had been collected, and it was hoped that further amounts would be given. At the Telegraph Jubilee dinner there was an attendance of 240. It was not proposed to fill up the post of honorary secretary, which had become vacant through the death of Col. Sir Francis Bolton; also the library would be placed under the charge of the secretary, and no librarian would be appointed. During the year life compositions to the amount of £92 had been effected, and a total of £114 had been invested by the trustees. As the title of the society was now considered hardly to represent the full scope of the work it embraced, it was proposed to change the name to the "Institution of Electrical Engineers," and this subject would be brought before a special meeting of members. At the conclusion of the reading of the report the usual votes of thanks were proposed and carried.

A paper was then read by Mr. A. C. COCKBURN on "Safety Fuses for Electric Light Circuits, and on the Fusing Points of the various Metals usually employed in their construction."

Mr. COCKBURN commenced by stating that much discredit had been brought on electric lighting by indifferent and bad work being put in installations; the overheating of cables had also caused fires. If proper cables were used, properly protected by proper fuses, perfect safety could be guaranteed. Cheap fuses were largely employed, but they were not safe and could not be relied on. Cut-outs were said to be absolute guarantees against fires, but cases had occurred in which the breaking of a lead had caused an arc to be started. There were many cut-outs in the market which have actually been the cause and not the prevention of fires. Cut-outs were often placed behind skirting boards without any outside protection, and in some cases a wire laid on wood had been used, a very dangerous arrangement. Such bad work only served to bring electric lighting into discredit. The metal wire used in fuses should not be less than 1¼ inch long, and it should fuse when a strength of current 100 per cent. above the normal passed. All lamps should be protected with fuses which would act promptly and at a less percentage than 100 above the normal current. Such fuses would not exceed one-fortieth of the cost of the lamp. Accumulators required to be protected by fuses, and not by magnetic cut-outs; both poles should be protected and not one only. Dynamo armatures should also be fitted with fusible cut-outs, and not be left to be their own fuses. In considering the whole question it was first of all necessary that the acting point of the fuse should be determined on; this acting point should be within 5 to 10 per cent. of the marked value. The fuses should not change by time and should not be liable to injury. The length of the fuse should be determined. The metal should not oxidise, and the wire should hang freely, as if it touched the holder it might crack the latter if it were of china or vitrite, and it might fire wood if the latter were not fireproofed. The size of the holders should be such that it would be impossible to insert wires other than the correct gauge. As the exact firing point of the fuses depends upon the size of the holders care should be taken that the latter are of proper dimensions. The metal contact screws should be large enough to carry three times the proper current without heating, and it is advisable to solder the connections; the latter are best made in the case of stranded wire by passing the latter clean into solid contact pieces and there holding them by a screw. The wires should not be bent round and held under the head of a screw. The incoming and outgoing wires should not cross one another, and to effect this the fuses should be set to the side of the break in the wires in which the fuses are inserted. The fuses should be easily replaceable when broken, and should be in sight, a glass or mica front being provided to the boxes in which they are inserted; this transparent front would prevent a defective fuse being inserted without being seen.

Mr. COCKBURN then exhibited various specimens of fuses which had been designed from time to time by different makers.

With reference to the effect of the holders in altering the fusing point of a fuse wire, it was found in one experiment that with a wire 62 mils. in diameter, a 5-inch length fused with 19 ampères,

a 3-inch length with 23·5 ampères, a 1½-inch length with 34 ampères, and a 1-inch length with 44 ampères. When tin wire was heated by the passage of a current, a film of oxide formed on the surface, which formed a hard tube. This tube enclosed and held up the molten metal inside, and prevented the wire breaking down until the current was considerably increased. In one case a wire which became molten inside with 5 ampères of current did not break down till the current was increased to 26 ampères. Professor Silvanus Thompson had devised a fuse in which a small ball of tin and lead alloy was suspended from the ends of wires bedded in the ball; the passage of the current melted the ball and caused it to drop off. Sir William Thomson had also designed a fuse in which the ends of two springs were held together by a tin and lead solder, which melted when a current passed, and allowed the springs to spring apart. Magnetic cut-outs were too cumbersome for general use, but would answer for the main leads if they did not stick; they had the advantage that they could be easily set back when they had acted. Lead wire for fuses was difficult to draw fine, and the metal was easily damaged. Copper was stronger, but it had the disadvantage that it became red hot before it failed; moreover, when heated and cooled several times, it became uncertain in its action. Platinum required to be raised to a very high temperature to fuse it. How then could a reliable fuse be obtained? This the author considered could be effected by the use of tin wire, which was weighted at its centre so that it broke immediately it softened, and before it had time to oxidise. Fuses constructed on this principle could be absolutely relied on. Nine fuses formed of 22 mils. wire were tried, and they broke down with the following currents:—

5·2 ampères.
5·4 „
5·2 „
5·2 „
5·3 „
5·1 „
5·4 „
5·2 „
5·2 „

5·25 average.

This showed that the wire could be relied upon to fuse at a definite point within a small percentage of range. The actual metal preferred was phosphor-tin, that is, tin containing about 5 per cent. of phosphorous; it melted at 235° C., a temperature which would not char wood. At this low temperature the effect of radiation was not marked, consequently the fuses could, if necessary, be placed in open boxes, and these boxes need not be of slate or china but of wood. The fuses could be made to act with certainty within 10 per cent. of their marked value. For main circuits four small fuses joined in multiple arc were preferable to one large one. In conclusion, the author claimed to have made a distinct advance in the subject beyond what had hitherto been done.

The discussion on the paper was adjourned till the next session.

The result of the ballot for the new Council was as follows:—

President—Edward Graves. *Vice-Presidents*—J. Hopkinson, F.R.S.; William Crookes, F.R.S.; Prof. Ayrton, F.R.S.; Alexander Siemens. *Members of Council remaining in Office*—E. B. Bright; R. E. Crompton: Prof. J. A. Fleming; Prof. George Forbes, F.R.S.; H. R. Kempe; Prof. A. W. Rücker, F.R.S.; Sir D. Salomons; Augustus Stroh. *New Members of Council*—Capt. P. Cardew, R.E.; Capt. Sir Douglas Galton, F.R.S.; Gisbert Kapp; Prof. Perry. *Associate Members of Council*—W. T. Goolden; W. M. Mordey; Major M. T. Sale, R.E. *Hon. Treasurer*—Edward Graves. *Hon. Auditors*—J. W. Blundell; F. C. Danvers. *Hon. Solicitors*—Messrs. Wilson, Bristowe, and Carpmael.

Physical Society, December 10th, 1887.

Prof. W. E. AYRTON, Vice-President, in the Chair.

Mr. C. A. C. Wilson and Mr. W. E. Sumpner, B.Sc., were elected members of the society.

Mr. H. G. MADAN described the "Optical Properties of Phenylthis-carbimide." This body, derived from aniline, is a colourless liquid, density 1·35, and of high boiling point 222° C. The refractive indices for the A and G lines are 1·639 and 1·707, respectively. It is thus seen to be a highly refractive liquid, and to have about the same dispersive power as carbon-bisulphide, whilst its use in prisms is unattended by many of the risks and inconveniences experienced with carbon-bisulphide.

"On the Recalescence of Iron," by Mr. H. TOMLINSON. If an iron bar, which has suffered permanent strain, be heated to a white heat and allowed to cool, the brightness at first diminishes and then reglows (recalesces) for a short interval. Under favourable circumstances as many as seven reglows have been observed during one cooling. Generally two decided ones are observed, one between 500 and 1,000° C. and the other below 500° C. The effects the author believes due to "rententiveness" of the material, somewhat similar to the causes of residual magnetism and residual charge of a Leyden jar. A table of experimental results giving the torsional elasticity and internal friction at different temperatures, for iron wire, showed sudden increases in internal friction at temperatures of about 550 and 1,000° C. The table also shows that the torsional elasticity slowly decreases as the temperature increases, whereas the internal friction increases enormously. This explains why bells cease to emit musical notes when heated.

Prof. FORBES believed the explanation of recalescence given by himself about 1873 is sufficient to account for the effects observed. This explanation postulates a sudden increase in thermal conductivity about the temperature at which recalescence occurs, which permits the heat from the inside to reach the outside more readily, and thus raise the temperature of the surface. The subsequent reglows observed by Mr. Tomlinson, he believes due to convection currents of air.

Prof. RUCKER suggested that calorimetric experiments might determine which view was the true one, and

Prof. AYRTON thought the question might be decided by having two half-round bars nearly in contact at their flat sides, heated up and allowed to cool, and noting whether any sudden change in the bending of each bar (due to unequal temperatures at the inner sides and outer sides) took place about the critical temperature.

"On the rotation of a copper sphere and of copper wire helices when freely suspended in a magnetic field," by Dr. R. C. SHETTLE. The author exhibited the apparatus with which his experiments "On the supposed new force" were made, the results of which were published in the *Electrician*, Vol. XIX. Dr. Hofford has recently made similar experiments, using brass discs, and his results seem to point to "diamagnetic non-uniformity" of the discs as the cause of the phenomena he observed.

CORRESPONDENCE.

The Late Compound-Winding Litigation.

"There is a river in Macedon and a river in Monmouth." There are two wires of respectively high and low resistance upon the field magnets of Varley's machine of 1876, and there are similarly two wires in Brush's machine of 1878. In my opinion, and what is of more importance, in the opinion of eminent electrical experts, the analogy begins and ends at that point.

To suppose that the incidental mention in Varley's specification of the employment of a high and a low resistance circuit for a purpose quite unconnected with self-regulation, covers the ground of what is generally known as compound-winding as described, claimed, and successfully carried into practice by Brush, would require no small stretch of the imagination; but I scarcely think that even Mr. Varley's well-known sense of self-abnegation would have restrained him from proclaiming himself in earlier days as the inventor of this very important and much discussed detail of electrodynamics, had he imagined himself to be so. In any case it would be interesting to learn why (so far as is within the cognisance of his electrical confrères) it seems to have taken Mr. Varley nine years (from 1876 to 1885) to make up his mind on the subject. For obvious reasons, however, I have no intention of arguing the merits of the case in the public journals.

I would for a moment refer to the leading article in your last issue, written, if I may say so, with the usual ability and evident desire for impartiality which characterises your journal, but from which the unjust inference might be drawn by those who do not know the facts of the case that the Anglo-American Brush Corporation has endeavoured to force a "monopoly" to the detriment of the electrical industry. I would therefore wish to state that although the Corporation has necessarily demanded a just recognition of its rights, it is well known that they have exercised the greatest patience and consideration towards both the manufacturers and users of infringing machines.

There has been no attempt to injure the business of the larger firms or to crush the smaller, or to harass in any way the customers of either who are using such machines (as is sometimes considered to be within the rights of patent monopolists), but the Brush Corporation has been willing from the first to grant licenses upon terms which can in no way hamper the industry, and which have been accepted by every manufacturing firm of eminence in the United Kingdom.

The directors of the Corporation certainly deserve some little credit for the conciliatory method they have adopted in enforcing rights for which large sums of money have been paid, and which, as the property of the shareholders, it is their duty to protect, but in respect of which they would neither claim nor accept

royalties unless they had clear evidence that they were legally and morally entitled to them.

John S. Sellon,
Vice-Chairman, A.A.B.C., Limited.

December 14th, 1887.

Edison and Swan United Electric Light Company v. Shippey Brothers.

As your report respecting the above in your last issue is incorrect and calculated to do harm to the cause we are fighting, we must ask you to correct same without delay, for in it you state that the plaintiff company has hitherto been successful in the action, thus imputing that we were beaten. Permit us to say this is not so, for in reality our position is stronger than ever, since the last trial. This case has never yet been fought on its merits, or even the validity of our claims to low resistance and fancy lamps been disputed ; this part of the action has yet to be decided by law, unless a settlement is arrived at. We are fully aware of the uphill work we have to contend with against such a powerful company, but we have still every confidence in our cause, and we mean to uphold our just claims to the last, and if properly supported by the trade financially we have no fear as to ultimate results.

We have always, as is well-known, upheld that Mr. Edison is clearly entitled to a carbon filament of small cross-section, if made from certain materials resilient in nature and of high resistance, burning in vacuo (say of 100 ohms and upwards as specified). This class of lamp we have never manufactured, nor even sold, therefore it does not concern us ; but when we come to take lamps of low resistance with rigid semi-metallic conductors as made by us, from 2 to 50 ohms resistance, suitable for battery lighting, also our improvements in bulbs for miner's safety lamps, fancy glass lamps for decorative lighting, also our ornamental standards and vases used in combination with glow lamps as fully described in our specification, then that is another matter altogether, and there is no law in existence, *or any expert that can truthfully say the description of lamps as sold by us under our patents are infringements of Mr. Edison rights*, nor will the company be able to set us at defiance so far as these claims are concerned, that is provided the trade give us their support promised at the public meeting held to discuss the matter. We may say that at present we have not asked for one penny towards the £1,000 or more spent by us over this matter. However, at the request of some leading firms, an appeal is about being made to the trade to subscribe the necessary funds towards defraying the expenses incurred by us to fully contest the points at issue in the interest of the trade ; but unless this is done, and proper support given, it can hardly be expected that we should continue the action entirely on our own account ; at the same time we are quite willing to continue the contest if a defence fund is formed for that purpose to pay costs, and we may here say that our case stands on an entirely different footing to the case decided against Woodhouse and Rawson, or even that of the "Brush" Company now pending.

The recent application of the Edison Company to the Chancery Court for an order against us for security of costs we consider premature, and it puts one very much in mind of the fable of the Lion and the Mouse, but there is also another tale told, in which the mouse choked the lion to death in trying to swallow him up for nothing but taking a few crumbs which the lion would not have missed.

Personally our firm has done more good than harm to the development of the electrical industry ; we have sold some thousands of our little battery lamps both in England and abroad, all of which, however, have done good work in sowing the seeds for the future harvest to come, and having spent some thousands of pounds in experiments, and much energy in building up our business to the extent it has grown, we are naturally jealous of our rights, and feel that we should at least share in a part of the profits of the lamp business, which means in case of monopoly about £100,000 a year for those that command the trade, upon which we may have something to say later on ; but, in the meantime, we are desirous that the trade should know how matters stand with regard to the legal position of

Shippey Brothers.

December 14th, 1887.

Metallic Circuits for Telephone Lines.

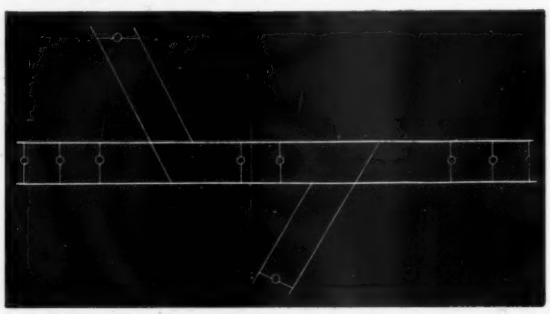
I read Mr. Bennett's article on "Metallic Circuits for Telephone Lines," in your issue of the 2nd inst., with much interest and pleasure, and feel sure that, while it specially applied to the construction of purely telephonic lines, it would convey useful hints to many who, like myself, are connected with mixed work, such as railway lines carrying large numbers of telegraph wires as well as occasional telephone circuits. Mr. Bennett's objections to the twist system of running telephone wires will be generally admitted, although in some respects it may be argued that they are not so considerable as alleged. For instance, the liability of twisted wires to get in contact is, I would say, more apparent than real, and it is certain that twisted wires will not warp and form permanent contacts so readily as straight wires, when the latter, like twisted wires, are run four on an arm.

This should not, however, be taken to indicate any preference on my part for the "twist system," as I am quite of Mr. Bennett's opinion that it possesses the element of unsightliness in a marked degree. On this account alone it should, I think, be avoided when satisfactory results are to be obtained by means of straight wires.

To obviate the disfigurement produced by twisted wires on telegraph lines, it has been the practice on this line (Caledonian) since 1880, when the first local circuit was fitted up, to run all telephone wires straight, without crossings, and put in the telephones on the parallel plan.

Excellent results have been obtained in every case, and quite recently an extended circuit on the same plan providing direct communication between ten stations, the two terminal stations being 32 miles apart, was completed and brought into operation without the slightest inconvenience being suffered from induction.

The circuit is a somewhat peculiar one, having two branches of some miles each run off, so :



Gower-Bell instruments with covering boards and concentrating mouth-pieces have been used, and the speaking between any two stations on the circuit is as good as if they were not more than 100 yards apart.

At first, I was somewhat doubtful of the possibility of working ten telephones satisfactorily on so long a circuit, but judging from the result it would seem that the extent of work only need limit the number of telephones on the circuit, so long as the necessary belling can be done. The relays, to designs by the superintendent, are of resistance equal to the line, and apportion the belling current equally between the various stations. It would be interesting to know if there is a longer circuit with an equal number of stations anywhere in the United Kingdom, and if so, how it has been constructed and is now wrought ?

It will be apparent, of course, that it is quite possible to extend the circuit very much, both in regard to length and number of stations.

Inspector.

December 13th, 1887.